# ECOLOGICAL STUDY OF *Crinum defixum* Ker. WITH SPECIAL REFERENCE TO PHYTOCHEMISTRY AND PHARMACOLOGY IN BUNDELKHAND REGION (U.P.)

*Thesis Submitted*

TO

THE BUNDELKHAND UNIVERSITY, JHANSI

**For The Degree**

OF

*Doctor of Philosophy*

IN

BOTANY



By

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**2008**

Dedicated
to
My Mother

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## DECLARATION BY THE CANDIDATE

I declare that the thesis entitled **"Ecological study of *Crinum defixum* Ker. with special reference to phytochemistry and pharmacology in Bundelkhand region (U.P.)"** is my own work conducted under the supervision of Dr. U.N. Singh, Reader and Ex-Head, Department of Botany, D.V. Postgraduate College, Orai (U.P.) as approved by Research Degree Committee. I have put in more than 200 days of attendance with the supervisor at the centre.

It is further declared that to the best of my knowledge the thesis does not contain any part of any work which has been submitted for the award of any degree either in this university or in any other University/Deemed University without proper citation.

Date : 2/6/08

**(Nivedita Singh)**
Signature of Candidate

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## SUPERVISOR'S CERTIFICATE

This is to certify that the work entitled **"Ecological study of *Crinum defixum* Ker. with special reference to phytochemistry and pharmacology in Bundelkhand region (U.P.)"** is a piece of research work done by Nivedita Singh under my guidance and supervision for the degree of Doctor of Philosophy in Botany of Bundelkhand University, Jhansi (U.P.) INDIA. That the candidate has put-in an attendance of more than 200 days with me.

To the best of my knowledge and belief the thesis :

(i) embodies the work of the candidate herself,

(ii) has duly been completed,

(iii fulfil the requirements of the ordinance relating to the Ph.D. degree of the University and

(iv) is upto the standard both in respect of contents and language for being referred to the examiner.

Date : 2/6/08

**(Dr.U.N.Singh)**
Signature of Supervisor/Guide

# ACKNOWLEDGEMENTS

I record my deep sense of gratitude to my research supervisor Dr. U.N. Singh, Reader and Ex-Head, Department of Botany, D.V. Postgraduate College, Orai for suggesting the research problem, providing constant inspiration, sagacious guidance and incessant encouragement throughout the research tenure.

My heartiest thanks are due to the Principal, Dr. N.D. Samadhiya, D.V. Postgraduate College, Orai for providing laboratory facilities and administrative backup. I wish to express my thanks to the staff of Botany Department, Dr. A.K. Yadav, Dr. R.K. Gupta and Dr. V.K. Yadav for their creative suggestions. My thanks are also due to the staff of Government Aurvedic College, Jhansi, who helped me in making available some valuable materials and laboratory facilities and encouragement to me in the completion of the thesis.

It is my pleasure to record sincere appriciation to my friends and colleagues Dr. Neel Ratan, Dr. Anuj Bhadauria and Dr. Neetu Singh of the research circle in the Department for their multifarious assistance.

I owe my heartly thanks to Mr. Ramesh Chandra Srivastava, Bhaiya Lal and Veer Bahadur the non-teaching staff of the Department for providing day to day help in the field and laboratory work.

I offer my profound respect and feelings to my loving parents

Late Smt. Gulab Devi and Shri Jai Govind Singh and only younger brother Mr. Vivek Kumar Singh without whose patience, sacrifice, blessing and co-operation, it could not have been possible to complete my research programme.

I would fail in my duties if I forget to record my thankful appreciation to my adorable Madam Smt. Usha Singh W/o Dr. U.N. Singh, the supervisor.

Lastly. I express my thanks to Mr. Pankaj Gupta, Poorvi Computers, Orai (U.P.) for typing the manuscript.

Date : 2/6/08

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# PREFACE

The present study is concerned about **"Ecological study of *Crinum defixum* Ker. with special reference to phytochemistry and pharmacology in Bundelkhand region (U.P.)"**. Ecological science seeks to determine the effects of environmental factors on growth, distribution and migration of the plants, animals and deals with the relationship of organisms and environmental factors.

Autecology a major subdivision of ecology is essentially the study of life histories and behaviour of individual organism or an individual aspect as means of adaptation to the environment. Studies on the phytochemistry and pharmacology with the life cycle of important species of the community are helpful to show the relationship between plant and men with environment. Thus a species being an integral part of an ecosystem needs special attention to classfy the dynamics of whole ecosystem. Since the incipient concept of ecosystem, ecologist around the world have become more interested in the study concerning the structural, compositional and functional aspects of communities for the improvement of global relationship between man and environment to increase man's ability to manage natural resources of the biosphere.

The studied plant which is commonly known as sudarshan belongs to family Amaryllidaceae is cultivated in Bundelkhand region and

other parts of India. Widely grown in tropical region and indigenous to India. It is found wildly in Assam, Orissa and Chota Nagpur. It has been collected from south of the equators in Celebes and New Guinea. Sudarshan is reported as endangered species by Botanical survey of India. In experiment these points were taken and observed the high level of cultivations in this region.

Sudarshan has a rich ethnobotanical history dating back possibly to the old statement of Charak Samhita, Bible, in early Greek and Roman medicine. Due to its medicinal properties the bulb of Sudarshan is used for the preventions of many diseases in children and women.

On the basis of the above features, different points have been selected for the study in relation to ecological aspect and all research work has been divided into twelve chapters. Introduction is first chapter, second chapter of material and methods includes detail about study site, different apparatus and methods which were applied during study. Chapter third is plant identification and forth is establishment studies which includes effect of temperature and water stress on the growth and field cultivation of plant. Chapter fifth has effect of nitrogen, phosphorus and potassium as fertilizer on the growth of plant. Next chapters i.e. 6, 7 and 8 have photoperiodic application, standing biomass, primary productivity and nutrient dynamics respectively. Phytochemical studies in 9th chapter contains different chemical constituents present in plant at different age group. Pharmacological studies include indentification of the plant as a drug

having diuretic properties. Finally discussion and summary of research work are given followed by references.

The aim of the present study is to provide the identifications of pharmacognostic interest of the plant under different ecological conditions. The investigation will lead to the formulation of ideas which will serve as important link between locality and natural occurrence of plant or place of collection. The detailed ecological description is essential for proper use of plant to achieve such objectives. The present study is an attempt towards this direction.

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# CHAPTER - I

# INTRODUCTION

# INTRODUCTION

Ecological investigation of several herbaceous and tree species have established the environmental influence on reproduction, phenology, primary production, metabolic status and conservation of solar radiation available on earth surface. The study of "growth analysis" reviewed by Watson (1952) is a good indicative of environmental influence on plant growth. The influence of various factors on growth parameters have been worked out by Friend *et al.* (1965), Thorne (1960). Simple NPK fertilizer experiments may yield some idea about the range of habitats in which nutrient deficiency and consequently competition occurs. Expensive changes in plant association have been reported to occur due to the use of these fertilizers (Bradshaw, 1969; Gray, 1983). According to Donald (1963) success of one species in sequestering a greater share of limiting nutrient may stimulate its growth to the extent that the activity of competing species may be suppressed by imposition of secondary factors resulting from different growth activities.

In recent years emphasis has been laid on the utilization of indigenously occurring vegetable and other herbaceous plants raw

materials for the production of drugs and pharmaceuticals. The pharmaceutical industry however, has to depend on the supply of such materials from forest areas till their cultivation becomes an economic proposition. Studies of the phytosociological relationship of such plants and correspondingly their distribution pattern may help in finding out the plant communities under which the plants have maximum frequency and density. These studies not only facilitate bulk collection from forest areas but may also help in devising suitable working plants for the exploitation of minor forest produce in the country (Sarin & Gupta, 1968).

The traditional use of plant for curing various human diseases in relation to its distribution and habitat is possible by the survey of different areas of plant growth. It is a basic knowledge before going in to the deep experimental study. The ethnobotany of some plants have been observed by several workers, Bist *et al.* (1990), Bhattaraj (1992), Motley (1994), Jain and Puri (1994), Rama Shankar *et al.* (1995).

Some of the world's leading botanist have warned of four-day conference on botanic garden in the Gram Canaria, in 1985, that nearly 15,000 plants are dangerously rare or moving to extinction. Additional "40,000 sp. could be lost before the middle of the next century", prediction made by Dr. Peter Raven, Director of

the Missuri botanical garden, (The Times of India, February 6, 1986). Twenty plant species of potential medicinal value have been listed as endangered species by B.S.I. One of the important plant *Crinum defixum* found in India is important to meet the medicinal demand in the country.

Different type survey methods for natural resources, their development and utilization namely aerial photointerpretation and integrated surveys have been discussed in detail by Quin (1964), Raheja and Sen (1964), Satyanarayana, (1965), Vink (1965) and Raheja (1966). Vink (1965) concluded that execution of integrated survey of resources is very long and time consuming investigation. He suggested that collection of data on different aspects taking into consideration and their importance in relation to development projects in the past decades, may be available more quickly.

Intercropping, domestication, micro-propagation and agro-techniques are the methods to grow the plant in large commerciable scale. For the proper growth and use of the plant, types of soil, manuring, planting methods, irrigation and weeding, harvesting, curing methods are required. Channakeshva *et al.* (1991), Nayar (1992), Philip *et al.* (1994), Harkrishan *et al.* (1997) and Jha and Gupta (1991) reported that *Crinum defixum* was found most suitable for intercropping with *Populus deltoides*.

Soil moisture and temperature regimes are of paramount importance in determining soil organic N mineralization rates. Major pules in N mineralization occur as a result of increase in microbial activity caused by alternate wetting and drying Birch (1958), Cabrera and Kissel, (1988). Greenland and Nye (1959) when gave a lack of a pronounced dry season and high constant temperature of isohyperthermic regimes encountered in the humid tropics, nitrogen mineralization rates are expected to be high.

An accurate analysis of the inorganic constituents of the plants give an inventory of the elements derived from the soil (Arnon, 1953) and is a very valuable and helpful means for determining the relatively nutritional status of plants (Cain, 1959). Puri (1954) has shown importance of leaf analysis methods in phytogeography, forest ecology and tree physiology. Puri (1954) and Jain (1960) have established relationship between soil and plant calcium in *Shorea robusta*. Bhatia (1956) carried out chemical analysis of leaves of *Tectona grandis* in Madhya Pradesh.

With the development of life on the earth, competition between organisms were started. Darwin (1959) first time gave the concept of competition between living organisms and after this in

ecosystem Tansley (1917) provided the first experimental demonstration of competition.

According to Weaver and Clements (1966) competition is a universal characteristic of all plant communities and is absent only in the initial stage and continuous to exist when the vegetation is stabilized. Theoretically competition may be defined as population of two species may interact in basic ways that correspond to combination. The species of community interact for water, light and essential nutrient elements (Odum, 1971). According to Harper (1961), Palmlad (1968), Gorden and Rice (1992), some time plant compete for space also. Depending upon the different type of interaction the competitive population was divided into several types by Haskell (1949) and Burkholder (1952). Similar studies were also conducted by Kozlowski (1949), Black (1960), Sakai (1961), Donald (1963), Singh and Doyal (1974), Berendse (1979), Antonovics and Lewin (1980), Szott (1987), Upadhyay and Chandrasekhar (1987), Tensor (1989), Stone and Roberts (1991).

Dry matter production by plants form the basis for understanding the energy capture in photosynthesis. It is a key function in the ecological life of plants and constitutes the basis for evaluation of the uptake of mineral elements and fixation of energy into plant body. The photosynthetic energy capture and dry matter prodction of plants may be understood through the study of their

seedlings. According to Medgwick (1973) the knowledge from seedling studies revealed that the total dry matter produced by young plant over the growing season may be drastically affected by the relative distribution of photosynthate to leaves, stems and roots. These studies are mainly concentrated in natural habitats (Bormann, 1958; Shiroyo *et al.*, 1962; Krueger and Errell, 1965; Krueger and Trappe, 1967; Ledig and Perry, 1969; Zimmermann, 1971; Ledig *et al.*, 1977; Lalman and Misra, 1981; Rana and Prakash, 1987; Tiwari and Choudhri, 1991.

Studies pertaining to the impact of progressive urbanisation in modifying the natural habitats in creating new habitats are extremely valuable in understanding the environment of man (Salisbury, 1933; Fitter, 1945; Tansley, 1954; Stamp, 1950). Dansereau (1957) and Ashby (1961) have stressed the importance of studying the flora at devastated sites.

The phytochemistry of *Crinum defixum* has been studied in details by Rao & Watson (1925), after that Maruzzulla *et al.* (1958), Nigam and Rao (1970), Saxena (1986), Dey *et al.* (1988), Lohar *et al.* (1992), Karwatzki *et al.* (1993), Narayana *et al.* (1995) and Agarwal *et al.* (1997) reported that the plant has higher oil content as well as higher percentage of the major component. Report on the occurrence of alkaloids in *Boerhaavia* has been made

by Nandi and Chatterjee (1974). Systematic studies on *Rauvolfia serpentina* have been made by Dutta *et al.* (1963). Chopra *et al.* (1956) reported medicinal properties of *Datura* sp. and Nandi and Chatterjee (1975), Nandi *et al.* (1976) analysed the factor of affecting alkaloid formation in these species.

Recently Bastida *et al.* (1995), Elgaroshi and Van-Staden (2004), Lee *et al.* (1995), Park and Chund (1996), Tolba (1996), Unver (2007) and Vronteli (2002) have done the pharmacological and germination studies of a number of species including *Crinum defixum*.

Dey *et al.* (1988) investigated, phytochemical studies of the bulb, root, leaf and flower of sudarshan. Microscopic examination of the cells, tissues, their distribution in different plant organs, nature of non-protoplasmic cell contents and differential microchemical response were made for the authentication of the drug samples. Physical constant values involving specific gravity, moisture content, and ash were studied. Quantification of the crude alkaloid, total sugar, protein, nitrogen and soluble nitrogen, spectrophotometric analysis of the pigments and fluorescence analysis were also studied.

Keller *et al.*(1985), Dombek *et al.* (1989), Schmidt (1993)

reported that beta-asarone is found as a main compound in sudarshan. Schmidt (1994) used the oil extracted from sudarshan and beta asarone to coat grains of maize and the effects on *Prostephanus truncatus* were investigated in the laboratory. Maize was also treated with bulb powder of sudarshan. Treatment with the oil reduced feeding by 50 percent within 21 days. A decrease in feeding was observed in maize treated with beta-asarone after 21-32 days at $30^0$C but not at $25^0$C. An admixture of bulb powder reduced feeding by 83 percent.

Riaz *et al.* (1995) described the botanical and chemical background of four species of genus *Crinum*. Numerous application of the plants as insecticides, plant growth inhibitors, antifeedents and hair growth stimulant have been described. The pharmacological studies of sudarshan bulb in drug preparation with varying content of beta-asarone have been described in detail since *Crinun defixum* having a high content of beta-asarone has been proved to be carcinogenic.

Essential oil present in sudarshan was observed by Nigam *et al.* (1987). Wu *et al.* (1994) and Todarova *et al.* (1995) studied the bulb oil of *Crinum defixum* analysed by the GC and GC/MS and 30 compounds were identified. The main ones were shyobonones

(17.3 percent) and acorenone (14.4 percent). Essential oil present in sudarshan growing in Turkey was studied by Tanker *et al.* (1993) and Mericle *et al.* (1994). Essential oils were obtained by water distillation and found 0.9-4.1 percent in leaves and bulb.

In the Charak Samhita, sudarshan i.e. *Crinum defixum* is described and used in mental disorder for boosting recall. In the past years pharmacological studies of the plant were done by Panchal *et al.* (1989), Mortis *et al.* (1991), Suru *et al.* (1995) and Thankamma *et al.* (1995). Borthothur (1992) reported that Sudarshan is used for prevention of many types of diseases in children and women of Assam.

Singh (1989) conducted the experiment to investigate the effects of sudarshan on escape/avoidance, conditioning and general motor activity of rats. A pilot study determined the optimal dose and found sudarshan to enhance learing performance, especially in the females, where as the effect of the drug on general activity was nonsignificant. The performance of the descendents of drug administered animals and the animals themselves given drug, continued to enhance. A case of maternal cytoplasmic inheritance is suspected. Similar type of investigation was also made by Zhau *et al.* (1992), Rafatullah *et al.* (1994) and Kulkarni and Verma (1995).

The plant sudarshan is used for the treatment of Asthma, insomnia, irritability, epilepsy, hysteria, diuretics and mental disorder. The medicinal properties of the plant were investigated by Dandiya (1987), Bucher *et al.* (1992), Mamgain *et al.* (1994), Tripathi and Singh (1994), Date and Kulkarni (1995), Singh (1995), Sencar *et al.* (1995), Gewali (1995), Ray *et al.* (1996), Uthapp and Sharma (1996). According to Prasad and Chakrabarty (1992) whose investigation deals with a study on hypotensive effect of *Crinum defixum* the bulb extract had produced a hypotensive response in dog B.P. It also exerted tranquilizing action but was less potent than chloropromaizine. There is a possibility to develop it into hypotensive agent but further studies are needed to assess its role as antiepileptic, antiasthmatic and anticarcinogenic agent.

Sharma *et al.* (1985) reported that sudarshan has been found to be highly effective in removal of roundworms in children. Its antibacterial, antipyretic and analgesic studies were done by Vohora *et al.* (1989). Bodam (1995) concluded that the antiherpes factor, not toxic to the host cells exists in the crude alcoholic extract of *Crinum defixum.*

Pesticidal, nematicidal and antifungal properties of sudarshan was studied by Saxena *et al.* (1987), Quamar and Chaudhary (1991). Ahmad *et al.* (1993), Singh and Upadhyay

(1993), Qureshi *et al.* (1994), Naik *et al.* (1995), Perrett and Whitfield (1995) and Charles (1995). Toxicity of essential oils found in *Crinum defixum* to mosquitoes was experimented by Sharma *et al.* (1985) and found favourable response.

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# CHAPTER - II

## THE STUDY AREA
## AND
## MATERIALS AND METHODS

# MATERIALS AND METHODS

## THE STUDY AREA

### Location and Topography

The present study deals with the **"Ecological study of *Crinum defixum* Ker. with special reference to phytochemistry and pharmacology in Bundelkhand region (U.P.)"**. The above study is conducted in the premises of Botanical Garden, D.V. Postgraduate College, Orai at lat. $25^0 59'$ N, long. $79^0 37'$ E and is about 141.61 meters above mean sea level in northern part of the Bundelkhand region (Fig. 2.1).

Bundelkhand is suitable for good growth of grasses and has a central position in the country. The site for investigation is a part of land bounded by Yamuna river in north, Betwa river in south and Madhya Pradesh State in the west.

Besides southern marginal area, the topography of this region is of undulating type. Trans-Yamuna plain is another name of Bundelkhand plain, which is topographically divisible into three east-west running belts i.e. Southern, Northern and Central belts. Orai is located in Northern belt and confined along the bank of the

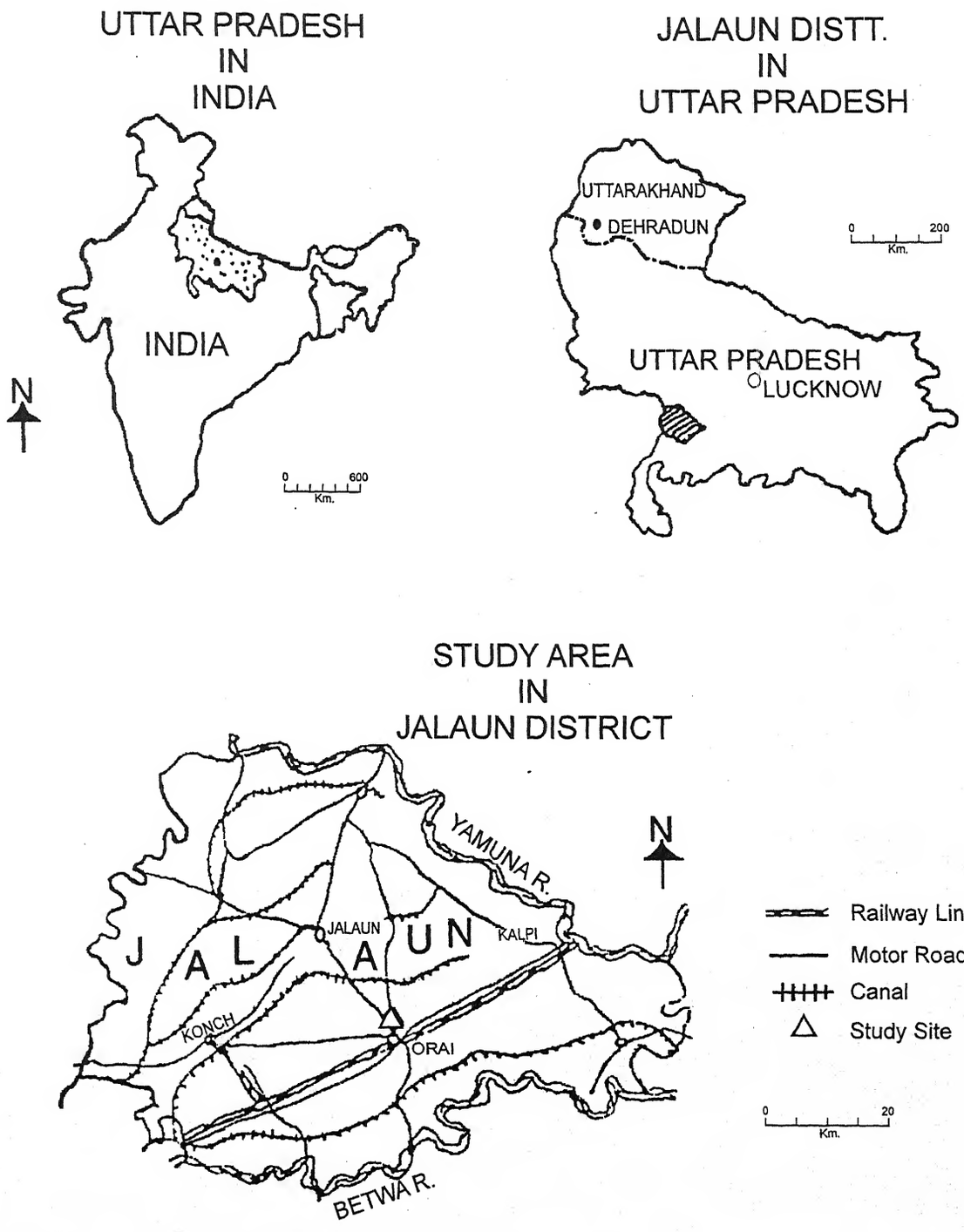


Fig. 2.1 : Map showing the location of study sites

river Yamuna in the form of high ground which represents the level of ancient flood plain but at present is badly cut into ravines.

## Lithology

Sand stones, lime stones and shales are the common rocks. The special features of immense geographical interest in this region are quartz, reefs and dolarite dykes which are long and narrow with serrated ridges. The geological system is covered in the north west and north east by Ganga-Yamuna alluvial deposits in the form of an 'embayment'.

## Natural Vegetation

The region is ecologically degraded and the original vegetation has almost been removed for inhabitation and cultivation. Shrubs and grasses represent the secondary growth throughout the region. Babul is the principal type of *Acacia.* Khair is the common tree but not much utilized. Hingota, Karondha and Kareel are mostly utilized for grazing.

*Albizzia procera* (Siris), *Anogeissus pendula* (Dhawana), *Tectona grandis* (Teak), *Butea monosperma* (Dhak), *Salmalia malabarica* (Semal), *Boswellia serrata* (Salai), *Dalbergia sissoo* (Shisham), *Acacia catechu* (Khair), *A. nelotica* (Babool), *Zizyphus mausitian* (Bair), *Carissa carandus* (Karondha), *Capparis aphylla* (kareel), *Balanites aegyptica* (Hingota), *Albizzia lebbek*

(Black Siris) are the main contributors in the natural vegetation of this region.

**Climate**

The climate of Bundelkhand Region is typically dry sub-humid and has a distinct seasonality. It is characterised by three seasons.

(i) Rainy season : (July to October) It is warm and wet.

(ii) Winter season : (November to February) It is cool and dry.

(iii) Summer season : (March to June) It is hot and dry.

The climatic records of Orai are summarized in Table 2.1 and depicted in Fig. 2.2A.

The summer season is dry and hot with scorching sun and strong westerly winds during the days. Maximum temperature rises up to 41.02$^0$c. The amount of rainfall in summer is usually low i.e. 229.3 mm accounting for about 24.34% of the total annual precipitation. The relative humidity in summer ranged between 25.3 to 66.6%.

The summer is followed by the warm and humid rainy season of about 4 months (i.e. July-October). Monsoon brings rain by the end of the June. The rainy season receives most of the rainfall (about 67.2% of the annual) resulting into a fall of

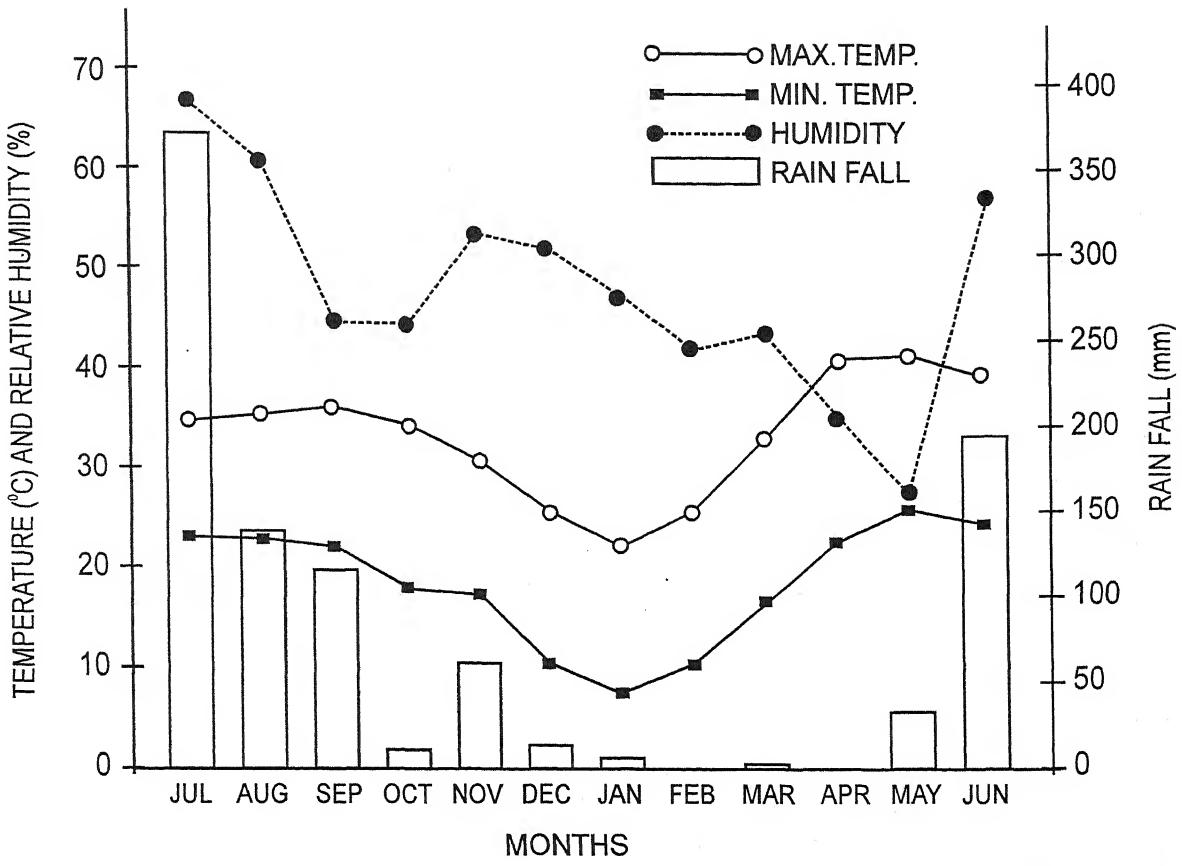


Fig. 2.2A : Climatic condition at Orai (2005-2006)

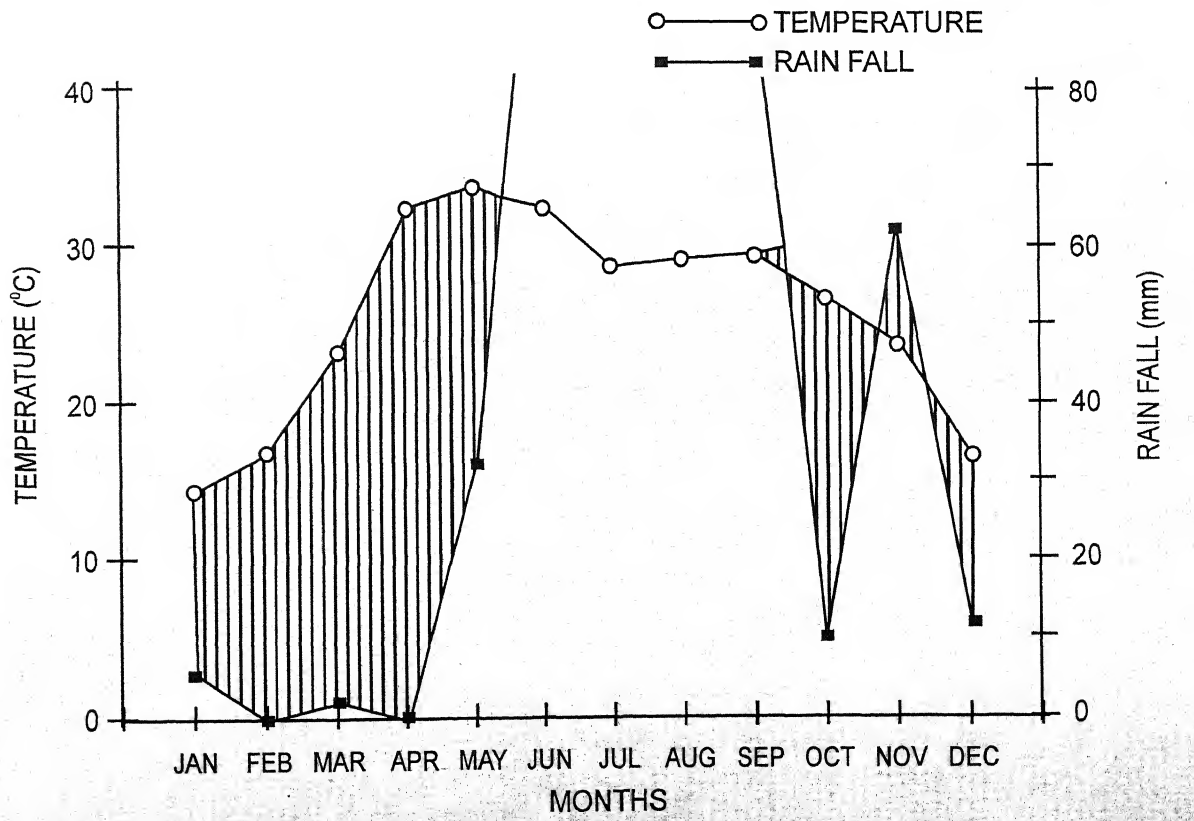


Fig. 2.2B : Ombrothermic diagram at Orai

**Table 2.1:** Climatic records at Orai (2005-2006)

| Months | Temperature | | | % Relative humidity | | | Wind velocity km/hr | | | Rainfall monthly (mm) | Solar radiation K cal/$m^2$x $10^3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean max. | Mean min. | Mean month | Mean morn. | Mean even. | Mean month | Mean morn. | Mean even. | Mean month | | |
| July | 34.82 | 22.93 | 28.87 | 69.16 | 64.71 | 66.59 | 3.55 | 4.55 | 4.00 | 371.20 | 67.83 |
| August | 36.16 | 22.90 | 29.06 | 62.48 | 58.03 | 60.25 | 4.13 | 4.38 | 4.25 | 136.40 | 52.70 |
| September | 37.30 | 21.78 | 29.50 | 53.90 | 35.40 | 44.65 | 1.73 | 3.13 | 2.43 | 115.20 | 52.20 |
| October | 34.94 | 18.31 | 26.62 | 49.70 | 39.58 | 44.64 | 2.00 | 2.48 | 2.24 | 10.40 | 64.63 |
| November | 30.96 | 16.70 | 23.83 | 57.13 | 50.13 | 53.63 | 1.66 | 2.46 | 2.06 | 62.10 | 50.40 |
| December | 25.27 | 8.51 | 16.89 | 54.70 | 50.20 | 52.45 | 1.74 | 2.45 | 2.09 | 11.80 | 48.20 |
| January | 22.50 | 6.07 | 14.28 | 54.30 | 40.90 | 47.60 | 2.38 | 2.32 | 2.35 | 5.30 | 53.78 |
| February | 26.24 | 7.36 | 16.80 | 49.90 | 34.80 | 42.35 | 1.80 | 3.33 | 2.56 | - | 59.64 |
| March | 33.20 | 13.27 | 23.23 | 44.70 | 43.00 | 43.85 | 2.58 | 3.35 | 2.96 | 1.80 | 67.89 |
| April | 40.99 | 21.30 | 31.14 | 39.50 | 31.10 | 35.30 | 2.60 | 4.37 | 3.48 | - | 76.80 |
| May | 41.02 | 25.86 | 33.44 | 22.10 | 22.90 | 27.50 | 3.45 | 5.74 | 4.59 | 33.00 | 82.46 |
| June | 39.86 | 24.55 | 32.20 | 61.56 | 52.33 | 56.94 | 2.33 | 3.46 | 2.89 | 194.50 | 75.90 |

atmospheric temperature to an average of 28.52°c. This is the season of maximum growth of the plant and biological activities. The average relative humidity during the season ranged between a minimum of 27.50% to a maximum of 66.59%.

The rainy season is followed by the winter season extending from November to February. The temperature begins to fall from early November and the coldest months are December and January. Days are sunny, bright and cool and nights are quite cold with minimum temperature going occasionally down to 6.07°c. The ground surface gets some moisture by dew formation early in the morning. The season is relatively dry with occasional sporadic showers in the month of January. Precipitation in winter is about 79.2mm i.e. nearly 8.41% of the total annual rainfall and the average relative humidity ranged between 42.35 to 53.63%. The total annual precipitation (i.e. from July, 2005 to June, 2006) was 941.7mm.

Gaussen (1960) has shown the effectiveness of the climatic factors like rainfall, monthly temperature and dry period during a year by means of Ombrothermic diagram. The same is depicted in Fig. 2.2B for the better understanding of the climatic factors. It is evident from this that an average, 8 month (i.e. November-June) were xeric during the study year when the thermic curve remained above the Ombric curve. Rest of the months were

wet and heavy rains were recorded mostly from last part of June to September

## Water Balance Computation

Water is a basic need of all organisms. In nature it exists in three different physical forms. The major sinks are ocean, ice caps of the mountain and poles, underground, lakes, rivers etc. Precipitation imparts a small fraction of it which keeps the land surface moist. Water supply on land, its utilization by living organisms and ultimate return to major storage pools keep on operating in nature through the hydrological cycle. A systematic analysis of this income and expenditure of water in any particular region known as "Water Balance Computation" lies in the moisture content of the soil which supports vegetation growing over it.

Following the method of Thornthwait and Mather (1955) the water balance computation sheet of the study area for the year July, 2005 - June, 2006 has been prepared (Table 2.2). Fig. 2.3 shows the water balance computation graph which has been drawn with the help of average precipitation, potential evapotranspiration and actual evapotranspiration which increase with an increase in the atmospheric temperature and decrease with increasing the relative humidity of the region. Actual evapotranspiration is governed by the water available for plant growth and soil moisture storage. In the rainy season, when there

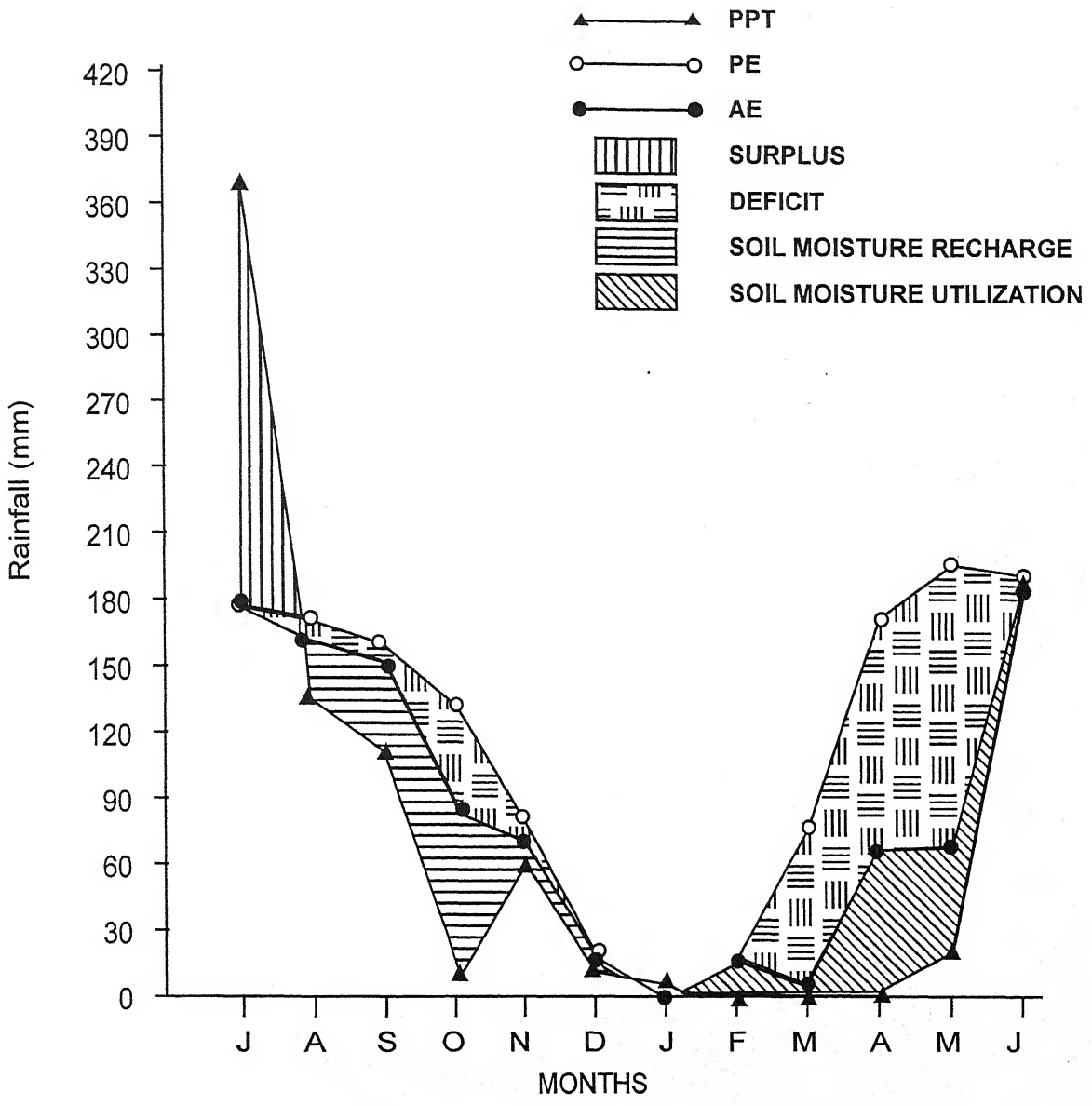


Fig. 2.3 : Water balance computation at Orai (2005-2006)

**Table 2.2 :** Water balance computation at Orai (2005-2006)

**Lat. N 25°59' 30"** **Long. E 79°3' 30" at 141.61 m a.m.s.l.**

| | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | Jun. | Average Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T°c | 28.87 | 29.06 | 29.54 | 26.62 | 23.83 | 16.89 | 14.28 | 16.80 | 23.23 | 31.14 | 33.44 | 32.20 | |
| i | 14.24 | 14.39 | 14.69 | 12.56 | 10.62 | 6.32 | 4.91 | 6.26 | 10.21 | 15.92 | 1.73 | 16.78 | 144.63 |
| UPE | 15.45 | 15.61 | 15.89 | 13.59 | 9.00 | 21.00 | - | 21.00 | 79.00 | 16.85 | 17.88 | 17.39 | |
| P E | 180.7 | 174.8 | 162.0 | 134.54 | 81.9 | 19.11 | - | 18.69 | 81.37 | 178.6 | 205.6 | 198.2 | 1435.42 |
| P (mm) | 371.2 | 136.4 | 115.2 | 10.4 | 62.1 | 11.8 | 5.3 | 0.00 | 1.8 | - | 33.0 | 194.5 | 941.7 |
| P-PE=Δ | 190.5 | -38.4 | -46.8 | -124.1 | -19.8 | -7.3 | 5.3 | -186.9 | -9.5 | -178.6 | -172.6 | -3.7 | |
| Σ Δ | 190.5 | -38.4 | -85.2 | -209.3 | -229.1 | -236.4 | 5.3 | -186.9 | -1.964 | -375.0 | 547.6 | 551.3 | |
| St | 237.5 | 264.0 | 225.0 | 149.0 | 139.0 | 136.0 | 141.3 | 160.0 | 155.0 | 85.0 | 47.0 | 47.0 | |
| Δ St | 190.5 | 26.5 | -39.0 | -76.0 | -10.0 | -3.0 | 5.3 | 18.7 | -5.0 | -70.0 | -38.0 | 0.0 | |
| AE | 180.7 | 162.9 | 154.2 | 86.4 | 72.1 | 14.8 | - | 18.69 | 6.8 | 70.0 | 71.0 | 194.5 | |
| W D | - | 11.9 | 7.8 | 48.14 | 9.8 | 4.31 | - | - | 74.57 | 108.6 | 134.6 | 3.7 | 403.42 |
| W S | - | - | - | - | - | - | - | - | - | - | - | - | |
| R O | - | - | - | - | - | - | - | - | - | - | - | - | |

T°C = Mean monthly temperature
i = Heat index
U P E = Unadjusted potential evapotranspiration
P E = Potential evapotranspiration
A E = Actual evapotranspiration
P = Mean monthly precipitation

Σ Δ = Summation data (Potential water loss)
St = Storage
W D = Water deficit
W S = Water surplus
R O = Run-off

was sufficient water for plant growth and soil moisture storage, the rate of actual evapotranspiration was found maximum by the end of rainy season (i.e. during October) when precipitation was less than potential evapotranspiration, a decrease in the rate of actual evapotranspiration was recorded and this decrease continued till April except a few exceptions due to occasional rains.

It is evident from Table 2.2 that soil moisture was being utilized by actual evapotranspiration in all the months excluding July. This utilization was maximum in June and minimum in January. As a result of this process, water deficiency was recorded in most part of the year. In the month of July when precipitation exceeds potential evapotranspiration, the excess of water was totally spent in soil moisture recharge. It is worth noting that there was no water surplus during the study year. According to Thornthwait system, based on soil moisture index value (-16.86) the present study area can be classified as dry sub-humid ($C_1$) which can be further classified on the basis of thermal efficiency, i.e. PE (=1435.42 mm) as micro-thermal (0-3 $C_1$). The value of summer concentration of thermal efficiency (S C T E = 40.57) comes to $a'_3$ symbol which clearly indicates that lower S C T E value means, high temperature uniformly month after month. Thus, ecoclimatic formula of the study area comes to $C_1$ $C_1$ $a'_3$ d where small d indicates no water surplus.

The various climatic indices worked out are :

Potential Evapotranspiration (PE) = 1435.42mm

Humidity Index

(Ih) = S/PE x 100 = 00

Aridity Index

(Ia) = D/PE x 100 = 28.10

Mosture Index

(Im) = Ih - 0.6 (Ia) = -16.86

Summer Concentration of Thermal Efficiency (SCTE) = 40.57

**Soil**

Soil is an useful resource to the man and is a component of environmental system. Thus it can be studied in terms of link between soil properties and process and other environmental components such as air, water, rock and life. In addition, the soil properties and processes which affect the use of soils by man are important topics for study. Soil develops when rock at the surface of the earth is changed by a series of processes, collectively known by the terms weathering. The rock is weathered and broken down by the combined action of water, gases and living matter. The formation of soil is not just a matter of the disintegration of rock; while the rock is disintegrating it is exchanging material with its immediate environment. A true soil is, therefore, a rock which has exchanged some material with its environment and the soil now

incorporates not only rock but also water, gases and both living and dead organic matter.

Soil conditions have a considerable influence on plant growth but often plant growth can not be thought of solely in terms of soil conditions. Other factors are also involved, such as genetic constitution of the plant, the climate, competition between different plants and infestation by viruses and fungi. Any one of these factors may limit the growth of plants. It follows that maximising plant productivity, in an agricultural context, or understanding plant distributions, in an ecological context, involves the study of many factors, not simply soil factor. Indeed, for many semi-natural vegetation types man has been the dominant influence. On the occurrence of plant species rather than environmental factors. Soil conditions should, therefore, be seen as one of many contributing factors influencing agricultural crop production and influencing plant ecology.

Plants may also have a significant influence upon soil characteristics. In particular, the nature and acidity of leaf litter can strongly influence the nature of the humus layers in soils which act to influence soil properties such as infiltration capacity. Plants may also influence the nutrient status of a soil, depleting it by nutrient uptake at the roots. Soil of the study site presents a nature profile

development. It is an old alluvial deposit. Agrawal and Mehrotra (1952) classified it as soil type III.

Soil samples were collected from studied site at the depth of 0-30 cm at each sampling dates of study period. Composite soil samples of each sample were taken for the analysis of all physical and chemical parameters of soils of the site. All the analyses were done on air dried basis, i.e. room temperature. The soil samples were passed through a sieve having 2mm holes in order to avoid the rootlets and stones.

## Soil Colour

It was estimated with the Munshell soil colour chart. Nomenclature for soil colour was expressed in colour names and Munshell notation recommended in the chart.

## Soil Moisture

Fresh soil samples were taken in the beaker and dried at 105$^0$C for 24 hours. The loss of moisture in fresh weight was calculated on the dry weight of soil (Misra, 1968).

## Soil Texture

It was performed by International Pipette Method as described by Piper (1966).

## Field Capacity, Water Holding Capacity, Bulk Density and Porosity

It was estimated by methods described by Misra (1968).

## pH

It was made by pH meter having glass-electrodes in a 1:5 soil water suspension (Misra, 1968).

## Organic Carbon

It was estimated by Walkley and Black's rapid titration method as described by Piper (1966).

## Nitrogen

It was analysed by Micro-Kjeldahl method as described by Jackson (1958).

## Available Phosphorus

It was estimated photometrically by the molybdo-phosphoric acid blue colour method as given by Jackson (1958).

## Exchangeable Cations

Exchangeable cations, i.e., potassium, calcium, acid sodium were extracted by leaching the soil with the adequate amount of neutral ammonium acetate solution. The concentration of the nutrients was estimated by Flame-photometer using different filters, i.e., potassium, calcium and sodium as described by Jackson (1958).

The physical properties of study site soil is given in the Table 2.3. The colour of the soil was light gray on dry but olive brown on wet. The texture of the soil was sandy loam. The percentage of sand, silt and clay were estimated 55.08, 27.10 and 17.81, respectively. The percentage of the sand was comparatively higher than silt and clay. The moisture content, bulk density, porosity, water holding capacity and field capacity are tabulated in the Table 2.3. The chemical properties of grassland soil, i.e. organic carbon, C/N ratio, pH, exchangeable cations are tubulated in the Table 2.4.

The physical and chemical parameters of study site soil are greatly affected by growth and development of vegetation. However, the significant effect of physical parameter of soil can be seen after longer period of time. Moisture content of the soil is dependent on the rainfall (Table 2.1). The bulk density was recorded 1.37 g/cc and as a general rule porosity is found to be inversely related to bulk density. The clay particle of the soil is more or less related to water holding capacity and field capacity (Sant, 1966). Man and Biosphere programme sponsored by UNESCO has given much importance on the carbon, nitrogen status of the soils. The main source of carbon and nitrogen in the soil is litter and decaying roots. Therefore, high amount of organic carbon was recorded on the soil due to low decomposition in the soil having

**Table 2.3 :** Soil colour, texture class, mechanical composition, moisture, bulk density, porosity, water holding capacity and field capacity of soils of study site

| **Physical Properties** | | |
|---|---|---|
| 1. Colour | : | Light gray 2.5 Y, 7/2 dry<br>Olive brown 2.5 Y, 4/4 wet |
| 2. Texture class | : | Sandy loam |
| 3. Mechanical composition | | |
| (a) Sand (%) | : | 55.08 ± 1.09 |
| (b) Silt (%) | : | 27.10 ± 0.48 |
| (c) Clay (%) | : | 17.81 ± 0.33 |
| 4. Moisture content (%) | : | 10.36 ± 0.42 |
| 5. Bulk density (g/cc) | : | 1.37 ± 0.05 |
| 6. Porosity (%) | : | 47.31 ± 1.88 |
| 7. Water holding capacity (%) | : | 46.09 ± 1.85 |
| 8. Field capacity (%) | : | 29.03 ± 1.17 |

**Table 2.4 :** Organic carbon, total nitrogen, C/N ratio, pH, exchangeable potassium, calcium, sodium and available phosphorus of soils of study site

| Chemical Properties | | |
|---|---|---|
| 1. Organic carbon (%) | : | 0.39 ± 0.02 |
| 2. Total nitrogen (%) | : | 0.03 ± 0.001 |
| 3. C/N ratio | : | 13.00 ± 1.46 |
| 4. pH | : | 7.30 ± 0.28 |
| 5. Exchangeable potassium (m.e.%) | : | 0.42 ± 0.03 |
| 6. Exchangeable calcium (m.e.%) | : | 3.31 ± 0.20 |
| 7. Exchangeable sodium (m.e.%) | : | 0.16 ± 0.01 |
| 8. Available phosphorus (ppm) | : | 126.00± 6.17 |

more moisture liberating much amount of nitrogen which was lowered the C/N ratio indicating slow rate of decomposition (Foth and Turk, 1972). The pH of the soil was found neutral on the soil. It may be due to faster decomposition of litter and formation of humic and fulvic acid. Most of the nutrients exist in minerals and orgaic matter and as such are insoluble so unavailable to plants. Nutrients become available through mineral weathering, organic matter decomposition and precipitation. The nutrients are absorbed from the soil solution or from colloidal surfaces as cations and anions. All the exchangeable cations were in high concentration because of addition of elements released by litter decomposition. The soil contained least amount of phosphorus as compared to other major nutrients. Less amount of phosphorus is required in the plants in comparison to other macro nutrients.

## THE METHODS OF STUDY

### Experimental Material

*Crinum defixum* Ker. belonging to family Amaryllidaceae is the experimental material. It is a perennial plant of herbaceous habit and mainly found in warm region.

## Experimental Site

In order to carryout the present investigation the plants are raised through bulbs in the field of Botanical Garden, D.V. Postgraduate College, Orai (Jalaun) with proper needed irrigation and other factors.

## Associated Plants of the Study Site

The vegetation of the study site before and after plantation of study plant has been given in Table 2.5.

## Culture Experiment

The culture experiment was set up in order to study the response of the plant at different age groups. Plants were grown in monoculture. The field was divided into main plot measuring 2x5 m size. The main plot was further subdivided into small units measuring 1 $m^2$ size. Seedlings were randomly selected and transplanted in the plot.

## Soil Analysis

The soil samples were collected from the surface upto 30 cm depth mixed uniformly and analysed for various physico-chemical properties.

**Table 2.5 :** Plant species found in the experimental plot before and after transplantation of *Crinum defixum*

| Name of Plant Species | Before site Preparation | Early stand | Mature stand |
|---|---|---|---|
| *Acalypha ciliata* Linn. | + | - | - |
| *Achyranthes aspera* Linn. | + | + | + |
| *Amaranthus spinosus* Linn. | + | - | - |
| *Blumea locera* D.C. | + | - | - |
| *Boerhaavia diffusa* Linn. | + | + | - |
| *Convolvulus pluricaulis* Chois. | + | - | - |
| *Cynodon dactylon* L. Pers. | + | + | + |
| *Cyperus rotundus* Linn. | + | + | + |
| *Dichanthium annulatum* Stapf. | + | + | + |
| *Euphorbia hirta* Linn. | + | + | + |
| *Euphorbia thymifolia* Linn. | + | - | - |
| *Evolvulus alsinoides* Linn. | + | + | - |
| *Eragrostis tenella* Benth | + | + | + |
| *Heliotropium strigosum* Willd. | + | + | + |
| *Oxalis corniculata* Linn. | + | - | - |
| *Pennisetum typhoides* | + | - | - |
| *Phyllanthus niruri* Linn. | + | + | + |
| *Sida cordifolia* Linn. | + | - | - |

**Physical Properties :**

**Mechanical composition -**

Mechanical composition was determined by the pipette method proposed by Piper (1966).

**Colour -**

The colour of dry and wet soil were determined by comparing with Munsell's soil colour chart (Munsell, 1905).

**Moisture content -**

Soil moisture content was calculated gravimetrically method described by Michael (1984).

**Porosity, bulk density and water holding capacity -**

These were determined by the method suggested by Misra (1968).

**Chemical Properties :**

Under, soil chemical properties, pH, exchangeable metallic cation (Potassium, Sodium, Calcium), total phosphorus, total nitrogen, total organic carbon were determined by methods as described by Jackson (1958).

pH of soil was determined by an Electronic pH meter. Exchangeable metallic cations were determined by Flame

Photometer. Total nitrogen content of the air dry soil was determined by micro Kjeldahl method, phosphorus by sulphomolybdic acid and chlorostannous acid method and carbon by titration method.

## Plant Analysis

The plant samples were collected at a regular interval of 30 days since the date of transplantation to harvesting time for various measurement. For correct statistical measurement three replicates from each sample were taken which were dug out randomly at a time without disturbing the other plants.

### Standing Crop Biomass :

The first sampling was done after 30 days establishment of bulb. At each sampling a monoliths of 25 x 25 cm was dug out upto a maximum depth of root. Monoliths of sampled plants were washed carefully to remove soil from the root and bulb. The plant parts i.e. above ground (standing live and standing dead) and under ground parts (bulb and root). The dug out plants were put in polythene bags. The plant were sorted into above ground and under ground part. The plant parts were put in oven at $80^0$C for 48 hours and were weighed. Sampling data of different parts of *Crinum defixum* were averaged and standard error was calculated.

**Net Primary Productivity (NPP) :**

Net primary productivity was calculated from the net biomass value at a particular time period and is expressed in $g/m^2/$ day (Briggs and Kid, 1920)

$$NPP\ (g\ m^{-2}\ day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1}$$

where, $W_1$ and $W_2$ are the dry weight of total plant at time $t_1$ and $t_2$ respectively.

**Physiological Analysis :**

The oven dried plant samples were powdered in a Mortar and passed through a 44 mesh sieve (0.353 mm, pore size) for the analysis of concentration of nitrogen, phosphorus, potassium, calcium, sodium and magnesium.

**Nitrogen -**

The nitrogen concentration was determined by micro-Kjeldahl method described by Jackson (1958). The oven dried samples of plant part (0.5 g) were digested in 10 ml concentrated $H_2SO_4$ using catalyst mixture (copper sulphate + potassium sulphate + selenium powder) for about 4-5 hours. The digest was collected and filtered through Watman filter paper No. 40 and made upto 100 ml. Adequate 10 ml was distilled with 40% NaOH in a Markham

micro Kjeldahl distillation unit. The distillate was collected in 4% boric acid and 2 drops of mixed indicator (0.5% of bromocresol + 0.1% methyl orange). The ammonia absorbed boric acid was titrated against N/28 $H_2SO_4$ and the percentage of total nitrogen was calculated by using the formula.

$$\textbf{Percentage nitrogen} = \frac{T - B \times N \times 10 \times 1.4}{S}$$

where, T = Volume of $H_2SO_4$ used in sample titration, ml

B = Volume of $H_2SO_4$ used in blank titration, ml

N = Normality of standard $H_2SO_4$

S = Weight of plant material, g

**Phosphorus -**

It was calculated colorimetrically as described by Jackson (1958).

**Calcium, sodium, potassium and magnesium -**

These were determined by Flame Photometer using the adequate of diluted digest prepared for phosphorus estimation described by Jackson (1958).

**Nutrient accumulation -**

The amount of nutrients stored in different parts of the

plant at various growth periods of plant were estimated by multiplying the dry weight of the plant parts with corresponding concentration of the nutrient.

**Nutrient uptake, retention and release -**

Nutrients are absorbed by plants from the soil and are retained by them in their biomass. A part of nutrients stored in the biomass is released through standing dead biomass. Nutrients enter into a variety of combinations with others organic compounds through metabolic activities. The uptake of nutrients is arrived at summation of mean absorption through retention process and release of nutrients through standing dead biomass.

These were calculated using the following formula:

$$\textbf{Uptake} = \frac{\text{Total accumulation of nutrients in above ground and under ground parts}}{\text{Number of days}} \quad (g\ m^{-2}\ day^{-1})$$

$$\textbf{Release} = \frac{\text{Total accumulation of nutrient in standing dead}}{\text{Number of days}} \quad (g\ m^{-2}\ day^{-1})$$

**Retention** = Uptake - Release

**Phytochemical Studies :**

**Qualitative studies -**

**a) Ash value**

Determination of ash value in any plant gives an idea of inorganic constituents and salts present in that plant. The total ash

values and acid insoluble ash were determined according to the following procedure :

**1. Total ash**

An accurately weighted amount (2-3g) of the air dried powder of the plant material was taken in a taffed crucible and incinerated by gradually increasing heat (not exceeding 450$^0$C) until free from carbon. It was then cooled and weighed. Three readings were taken for the accurate percentage calculation of total ash value.

**2. Acid insoluble ash**

The total ash obtained as above was boiled separately with 25 ml of dilute hydrochloric acid for five minutes. The insoluble matter in each case was collected on ash less filter paper, washed with hot water, ignited, cooled and weighed. The percentage acid insoluble ash was then calculated with reference to the air dried plant material.

**b) Solubility**

Solubility of plant drug in water and alcohol was determined by the following procedure :

**1. Solubility in water**

Macerated 4.5 g, coarsely powdered plant material with 100 ml of water for 20-24 hours. During maceration shaking was

done frequently and allowed to stand for 15- 18 hours. Filtered rapidly, taking precaution against loss of solvent and 25 ml of the filtrate was evaporated to dryness upto constant weight of the dish. Percentage of water soluble extractive value was calculated with reference to air dried plant drug.

**2. Solubility in alcohal**

Same above procedure was used. Alcohol (Ethanol) was used instead of water.

**Preliminary Phytochemical Investigation :**

The plant materials were subjected to preliminary investigations by extracting the drug powder with different solvents i.e. petroleum ether, chloroform, alcohol, water and testing was done for the presence of various plant constituents in them.

**Petroleum ether -**

150 g of the powdered drug was extracted with petroleum ether in (b.p. 60-80$^0$C) in a Soxhlet extraction apparatus by hot continuous extraction process till complete exhaustion. The extract was filtered and the volume of the extract was adjusted with petroleum ether. A portion of it was taken in a tarred beaker. It was evaporated to dryness and the residue dried to a constant weight. The percentage of petroleum ether soluble extract was then calculated.

**Chloroform -**

The ether extraction in excess was extracted again with chloroform as given above till complete exhaustion. The percentage of chloroform soluble extraction was then determined by following the usual procedure described above.

**Alcohol -**

The chloroform extraction in excess was dried at room temperature and was extracted with alcohol (Ethanol 95%). The percentage of alcohol soluble extractive was determined by following the usual procedure described above.

**Water -**

5 g of the air dried powder of plant material was macerated with 100 ml of water in closed conical flask for 22-24 hours with frequent shaking. It was then filtered and 25 ml of the filtrate was evaporated in a tarred shallow dish and the residue was obtained to a constant weight at 100°C. The percentage of water soluble extract with reference to the air dried drug was determined.

**Testing of the Extracts :**

The presence or absence of common plant chemical constituents in the fraction of different extracts obtained above were tested according to the following procedure.

**Alkaloids -**

It was determined by the method proposed by Geissman & Crout (1969). A portion of the fraction was acidified with dil. HCl. Then added a few drops of Dragendorffs reagents. Orange precipitate indicates the presence of alkaloids.

**Reducing sugar -**

Presence of sugar was determined by the method described by Mishra and Rao (1960).

**Protein -**

Presence of protein was determined by the method proposed by Plummer (1979).

**Volatile oil and other -**

Presence of volatile oil, lignin, mucilage, cutin, suberin were made from section treated with different concentration of acid, alkaloids, salts and dyes. Reactions were observed under the microscope, described by Plumer (1979).

**Quantitative studies -**

**a) Total alkaloid**

Crude alkaloid content was determined after Trease and Evans (1972) proposed by Evans *et al.* (1983). Bulbs and roots

were successively extracted by Soxhlet Extraction apparatus. Alkaloid positive fractions were separated by column chromatography and thin layer chromatography.

**b) Total sugar**

Total sugar was estimated by copper reduction method proposed by Harding and Down (1933) and Van der Plank (1936).

**c) Total nitrogen and protein**

The total protein and nitrogen fraction were estimated after Kjeldahl's method modified by Parnas and Wagner as described by Pregl (1930).

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# CHAPTER - III

# PLANT INDENTIFICATION

## PLANT IDENTIFICATION

### TAXONOMICAL DETAILS

### Classification

| | | |
|---|---|---|
| Division | - | Spermatophyta |
| Sub-division | - | Angiospermae |
| Class | - | Monocotyledones |
| Series | - | Epigynae |
| Family | - | Amaryllidaceae |
| Genus | - | *Crinum* |
| Species | - | *defixum* Ker. |

***Crinum defixum* Ker.**

### Synonyms

| | | |
|---|---|---|
| Hindi | - | सुदर्शन |
| English | - | Sudarshan |

## Habit and Habitat

*Crinum defixum* Ker. is an perennial herb with large tunicate bulbs, erect narrowly ensiform glossy green leaves, arising from a partially underground bulb (Plate I & II). It is found in warm region like tropical Asia, Africa, Australia and America mostly on sea coasts and in India often found wild in rocky beds of rivers. Cultivated within upper Gangetic plain and in other parts of India. Probably wild in Bengal and in Central Provinces in Swamps and beds of rivers.

## Morphology

**Leaves :**

Simple, alternate, distichous, very closely, arranged, vertically oriented, linear to narrowly ensiform, long and half to one inch broad, glossy bright green, and a broad amplexical base. The base is continued some distance upwards as a frebly split sheath enclosing the next younger leaf on the opposite side. The upper half which constitutes the blade is slightly broader, long and narrow with an acute apex. A thickened or stood midrib like region extents along the entire length of the leaf.

Flowering were seen in plants during experimental period (within two years).

**Plate I :** Showing habit of the plant at vegetative stage.

**Plate II :** Showing habit of the plant at flowering stage.

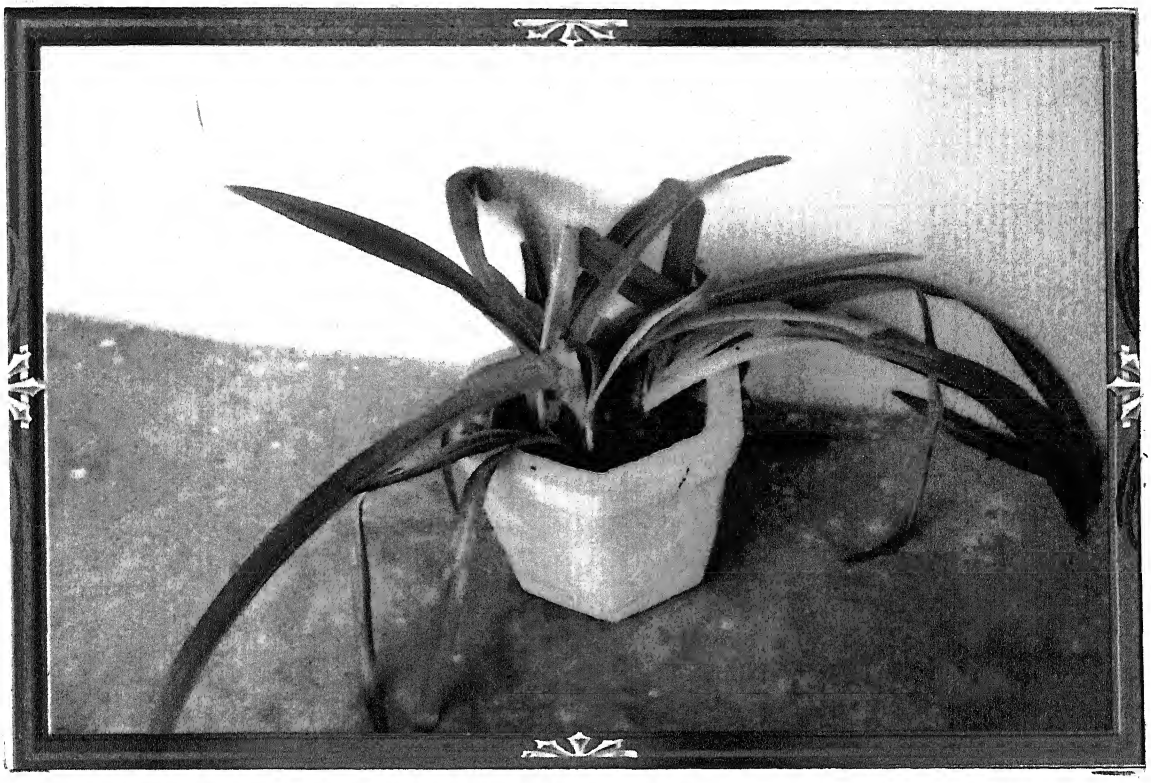

**Plate III** : Intact plants showing roots, tuber and leaves.

**Bulb :**

It is tunicate with fusiform stoloniferous base underground with fairly thick long adventitions roots. Neck of the bulb 2.5 in or less across (Plate III).

**Flowers and Seeds :**

Flowers large, white in colour, umbellae 6-12 fid., umbellate, sessile or nearly so with two spath like bracts at the top of a long solid scape, bacteoles linear. Perianth- funnel shaped or almost salver shaped, tube long, straight or incurved, cylindric or with a wide mouth; lobes 6, recurved or spreading or conniving, stamens 6, adnate to the throat of perianth-tube, filaments free. Ovary 3 celled; ovules 2-many in each cell; style filiform, stigma small. Fruit a sub globose membranous or coriaceous capsul, bursting irregularly. Seeds few, large, testa thick, albumen copious.

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# CHAPTER - IV

# ESTABLISHMENT STUDIES

# ESTABLISHMENT STUDIES

According to Corker and Barton (1953) the seed habit in plant has developed over a long period of time and represents highest type of plant development. Seed and vegetative part of the plant are responsible for regeneration of plants through its germination and establishment. Establishment and germination studies are of much importance for intensive investigation, preliminary selection of species and in respect of their suitability in any specific environment.

Effects of water stress on seed germination have been studied by several workers i.e. Harris and Pittman (1919), Manohar and Heydecker (1964), Strogonov (1964), Bhumble *et al.* (1966), Malival (1967), Redmann (1974), Varshney and Baijal (1977). But very little attention has been paid to the vegetative reproduction studies of individual species in mastering the habitat or organising plant communities. In such type of reproduction, new individuals arise out of the vegetative organs. The 'individuals' are, infact, portions of

the original parent. Apart from the rare occurrence of vegetative mutation usually associated with hybrid originate from the parent stock.

*Crinum defixum* usually propagates by bulbs. Vegetative propagation by bulb is a good method of reproduction and by which the healthy and genetically similar plants are obtained and they thrive best (Sant, 1965).

This chapter deals with the establishment level of bulb (as a vegetative part) in respect to different temperature and water stress.

## MATERIALS AND METHODS

Mature plant bulbs were collected from Nursery of Orai Forest Division of the same size (4 cm in dia.). The plant transplanted in the month of Sept.2005, became mature in June 2006 for study. These collected bulbs are stored under laboratory condition and moisture stress (i.e. kept in moist straw).

From the collection, 11 bulbs were kept in seed bed (tray) with garden soil and the proper moisture in soil was maintained throughout the experiment. For the temperature treatment the seed beds were kept under different temperature i.e. ranging from $5^0$C to

35$^0$C in seed germination chamber. The reading of the data for establishment of bulb is given in Table 4.1.

Similarly the experiments for water stress were set up by keeping 11 bulbs in each flower pot with garden soil in the Botanical Garden, D.V. Postgraduate College, Orai under natural condition. The flower pots were watered as follows :

| | |
|---|---|
| - 1st set of flower pot with bulb and nursery soil. | - watered daily to the level of water saturation |
| - 2nd set of flower pot with bulb and nursery soil. | - watered after two days but saturated at the time of watering |
| - 3rd set of flower pot with bulb and nursery soil. | - watered after four days and not saturated but well moisturised |
| - 4th set of flower pot with bulb and nursery soil. | - watered after six days but not well moisturised |
| - 5th set of flower pot with bulb and nursery soil. | - Not watered |

The watering was done for 30 days and the observations are given in Table 4.2.

The experiment for field cultivation, mature bulb buds collected from nursery of Orai Forest Division were transplanted in

**Table 4.1 :** Percentage establishment of vegetative bulb buds at different temperature

| Temperature ($^0$C) | Percentage establishment | Time taken in establishment (Days) |
|---|---|---|
| 5.00 | 27.27 ± 0.82 | 30.08 ± 0.09 |
| 10.00 | 36.36 ± 1.99 | 25.33 ± 0.76 |
| 15.00 | 63.64 ± 0.19 | 20.62 ± 0.06 |
| 20.00 | 90.91 ± 1.27 | 15.13 ± 0.45 |
| 25.00 | 81.82 ± 0.24 | 20.00 ± 0.60 |
| 30.00 | 72.73 ± 0.22 | 30.13 ± 0.30 |
| 35.00 | 45.50 ± 1.36 | 40.00 ± 0.00 |

± = Standard Error

**Table 4.1 :** Percentage establishment of vegetative bulb buds at different temperature

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| 10.00 | 36.36 ± 1.99 | 25.33 ± 0.76 |
| 15.00 | 63.64 ± 0.19 | 20.62 ± 0.06 |
| 20.00 | 90.91 ± 1.27 | 15.13 ± 0.45 |
| 25.00 | 81.82 ± 0.24 | 20.00 ± 0.60 |
| 30.00 | 72.73 ± 0.22 | 30.13 ± 0.30 |
| 35.00 | 45.50 ± 1.36 | 40.00 ± 0.00 |

± = Standard Error

**Table 4.2** : Percentage establishment of vegetative bulb buds at different water stress

| Watering Frequency | Percentage establishment (%) | Time taken in establishment (Days) |
|---|---|---|
| 1. Watered daily | 36.37 ± 1.09 | 30.33 ± 0.92 |
| 2. Watered after two days | 91.00 ± 1.65 | 25.41 ± 0.51 |
| 3. Watered after four days | 54.60 ± 1.27 | 20.25 ± 0.41 |
| 4. Watered after six days | 27.28 ± 0.55 | 32.38 ± 0.96 |
| 5. Not watered | 9.09 ± 0.18 | 40.00 ± 0.00 |

± = Standard Error

Botanical Garden, D.V. Postgraduate College, Orai having sandy clay soil. The climate is characterised by typical monsoonic type of tropical climate. All the ecological factors like temperature, rainfall, relative humidity and wind with their characteristic fluctuation make out three distinct seasons, namely, rainy, winter and summer, having well defined vegetational demarcation.

The bulbs were transplanted in the last week of the June in wet soil land, which is ploughed 2-4 times. Spacing between rows of plantation vary from 25 to 50 cm. Then bulbs were pressed under soil upto a depth of 4-5 cm. After transplantation the field was well irrigated and a constant water level is maintained till maturity of the plant. Crop was ready for harvest after one year of transplantation. Harvesting was done to dig up the bulb.

## RESULTS

### Effect of Temperature

The effects of temperature on the percentage establishment of bulb buds of *Crinum defixum* Ker. was studied and the results are presented in Table 4.1 and Figure 4.1. It was observed from the table that low and high temperature adversely affected the

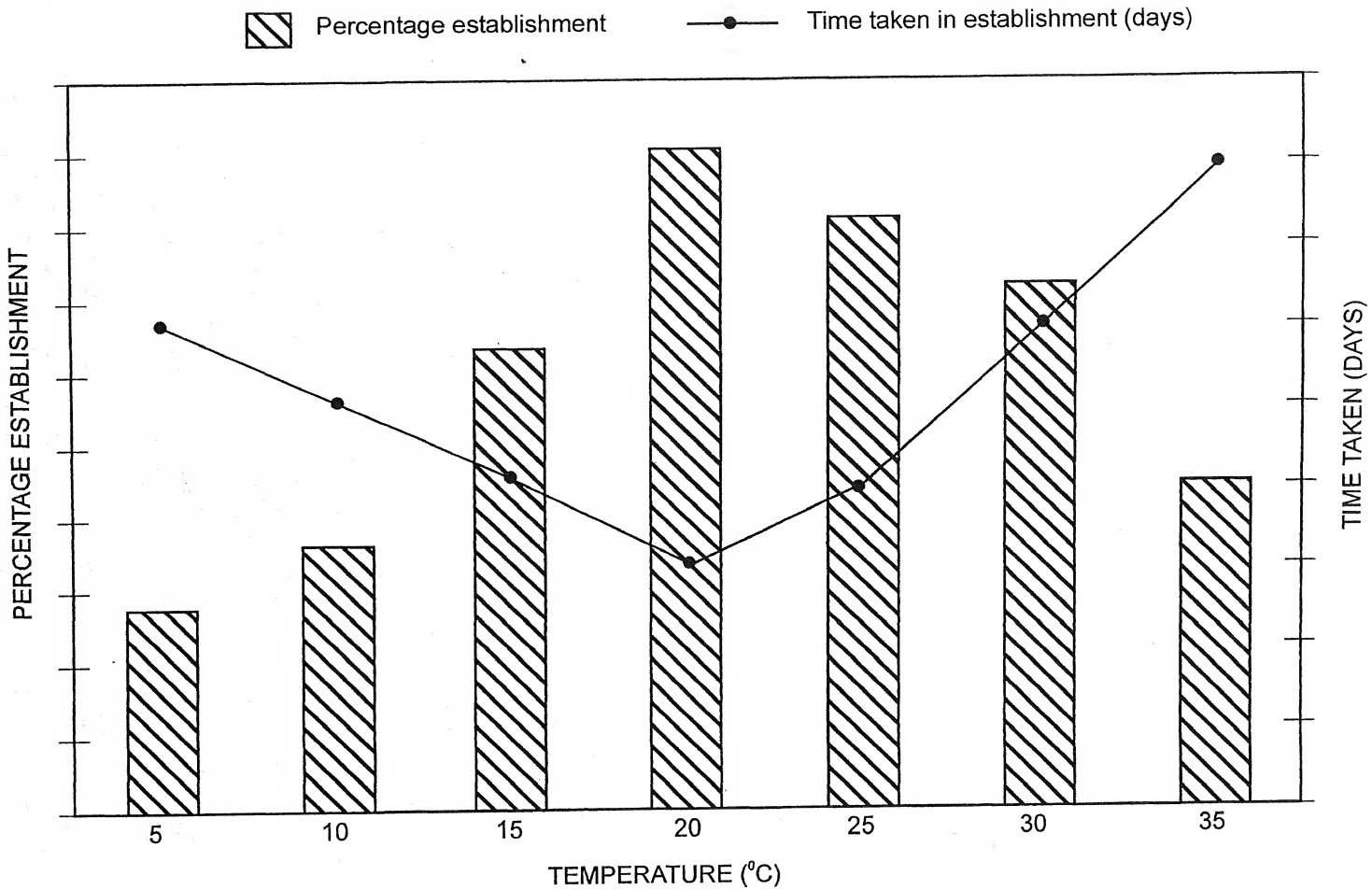


Fig. 4.1 : Percentage establishment at different temperature

percentage establishment of bulb buds. At low temperature i.e. $5^0$C, the establishment of the bulb bud was very poor and it was delayed for establishment also. It was observed that the most favorable temperature for establishment of bulb bud is $20^0$C in which 90% establishment was found.

**Effect of Water Stress**

The results of water stress study shows that the percentage establishment of bulb bud was the best in well moisturised pot i.e. 91% which was watered after two days interval and saturated at the time of watering. As the water stress decreases the percentage establishment of vegetative buds goes on decreasing and it shows poor percentage establishment in the soil which was not irrigated (Table 4.2 and Figure 4.2). The flower pot which was always saturated with water, shows poor establishment.

The bulbs which were obtained from cultivated field were of good quality due to their proper maintenance, irrigation and manuring. The better yield depends upon the fertility of the soil. Before planting the field is ploughed 3-5 times and left for few days with standing water. By this technique the soil becomes soft and wet

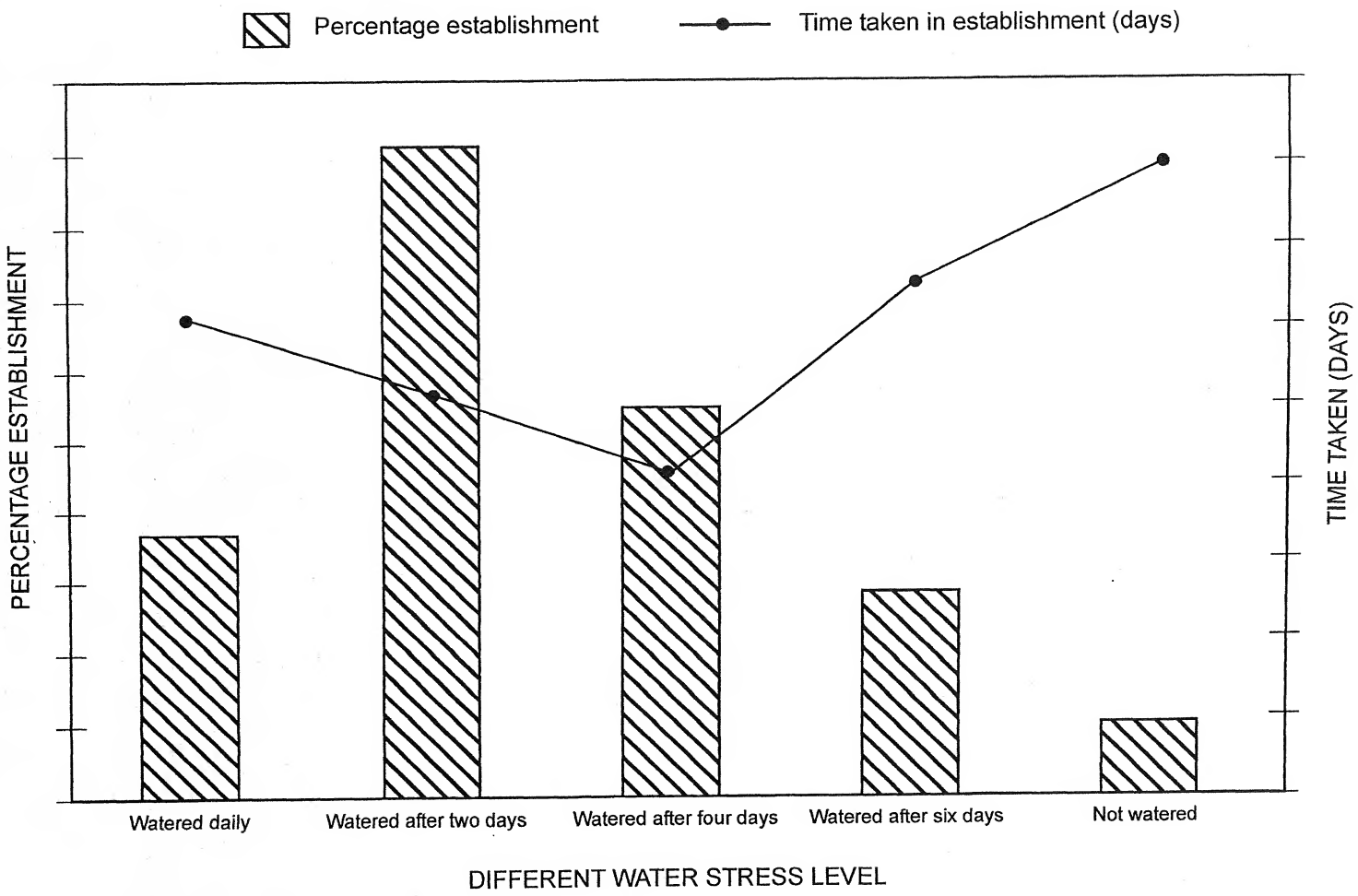


Fig. 4.2 : Percentage establishment of vegetative buds at different water stress

which allows the bulb for good growth. Green manuring are better than chemical manuring to obtain drugs free from harmful elements.

Young bulbs are preserved for the next crop as seed material under moist straw or dry leaves.

**Field Cultivation of *Crinum defixum***

Field cultivation of medicinal plant is important technique to prevent the plant species for endangering and also safe for providing the medicinal demand of the country. In India *Crinum defixum* commonly found in Upper Gangetic Plain and in other parts. *Crinum defixum* is reported as endangered species by B.S.I. (Botanical Survey of India) (Agarwal, 1987).

The plants are grown widely in tropical regions, but for proper maintenance, timely transplantation and irrigation is required. It was observed that this plant are also cultivated at a high level in eastern part of the Upper Gangatic Plain. Gupta (1970) studied in detail the developmental physiology of *Nicotiana plumbaginifolia* and Misra (1972) reported on the anti-cancer properties of the alkaloids in this plant with its cultivation. Lama and Chatterjee (1976) published in detail the cultivation practices of commonly occurring species of *Cinchona* in Darjeeling district. Scientific

cultivation of *Dioscoreas* and extraction of their active principles have been reported by Bammi and Randhawa (1972), Nandi and Chatterjee (1977).

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# CHAPTER - V

# FERTILIZER APPLICATION

# FERTILIZER APPLICATION

The composition of plant ash varies both with the species and with the environmental conditions under which the plant has developed. Different species of plants contain very different proportions of the various elements obtained from the soil. The composition and other properties of the soil in which a plant is rooted will also have an effect on the proportion of each of the various elements absorbed by that plant. Examples of this fact can be cited from the practice of fertilization. Addition to the soil of a compound which can be absorbed by plants usually results in an increased absorption of that substance by the plants although the increase in the amount of the element within the plant tissues is usually not proportionate to the increase in the amount of that element in the soil. Plants often absorb mineral salts from the soil far in excess of their actual metabolic requirements. Potassium, nitrogen, phosphate and other ions often accumulate in plant cells in excess of the quantities actually utilized by the cells.

The fundamental physicochemical properties of soils result largely from components present in the colloidal state. In most soil, colloidal fraction is made up principally of clay micelles, but organic

matter, when present in any considerable quantities is also an important constituent of the colloidal fraction of the soil. Under certain condition, cations of one kind can be displaced from clay particles and replaced by cations of another kind. The addition of inorganic fertilizers to soil often exchanges of cations between the clay particles and the soil solution.

Among the various minerals required by the plants such as nitrogen (N), phosphorus (P) and potassium (K) play a key role in cellular function which ultimately affect the growth of plants. The importance of these elements for growth of certain plants have been studied by several workers Palanianppan and Long (1973), Subrahmanyam and Varshney (1974), Misra *et al.* (1983), Mohmood and Rao (1992). The different organs of plant are variously affected by deficiency or efficiency of various minerals which in turn affect the rate of production. The present investigation was taken up to assess the effect of nitrogen, phosphorus and potassium on biomass production of *Crinum defixum* Ker.

## MATERIALS AND METHODS

The work was conducted during the year of 2005 to 2006. Mature plant bulbs of the same size (4 cm in dia.) were collected from nursery of Orai Forest Division. These bulbs were germinated

in sandy loam soil under shade of a tree. After germination each seedling was transplanted in an earthen pot (30 cm diameter in size) filled with garden loamy soil at three leaved stage in Botanical Garden of D.V. Postgraduate College, Orai. Only one seedling was planted in each pot. A standard amount of nitrogen, phosphorus and potassium elements was added in form of ammonium sulphate, calcium phosphate and potassium sulphate solution, respectively. Thus each pot of three treatments contained about 1 g, 0.5 g and 0.5 g of nitrogen, phosphorus and potassium respectively. Water was supplied frequently to keep the moisture level sufficient for the growth of plant. Observations were taken to dig out the whole plant from the pot at different time of interval. Different parts of plant were separated and dried in oven at $80^0$C for 48 hours after taking the preliminary observations. The dried parts were weighed for biomass estimation.

The leaf area was determined by planimeter. Net primary productivity was calculated from the net biomass value at a particular time period and is expressed in g/plant/day (Briggs and Kid 1920).

## RESULTS

The distribution of dry matter in leaf and bulb with root at different growth stages of plant has been estimated. The result

**Table 5.1** : Effect of nitrogen on biomass (g/plant) of *Crinum defixum*

| Age of plant (days) | Biomass | | |
|---|---|---|---|
| | Leaf | Bulb with Root | Total |
| 90 | 0.024 ± 0.002 | 0.053 ± 0.005 | 0.077 |
| 120 | 0.046 ± 0.012 | 0.086 ± 0.007 | 0.132 |
| 150 | 0.231 ± 0.051 | 0.418 ± 0.073 | 0.649 |
| 180 | 0.783 ± 0.020 | 1.08.5 ± 0.043 | 1.868 |
| 210 | 1.694 ± 0.086 | 2.768 ± 0.721 | 4.462 |
| 240 | 2.936 ± 0.145 | 4.560 ± 0.316 | 7.496 |
| 270 | 4.352 ± 0.427 | 6.685 ± 0.154 | 11.037 |
| 300 | 4.864 ± 0.265 | 7.324 ± 0.163 | 12.188 |
| 330 | 4.271 ± 0.370 | 8.692 ± 0.821 | 12.963 |
| 360 | 3.542 ± 0.536 | 8.953 ± 1.370 | 12.495 |

± = Standard Error

**Table 5.2 :** Effect of phosphorus on oven dry biomass (g/plant) of *Crinum defixum*

| Age of plant (days) | Biomass | | |
|---|---|---|---|
| | Leaf | Bulb with Root | Total |
| 90 | 0.041 ± 0.010 | 0.069 ± 0.031 | 0.110 |
| 120 | 0.397 ± 0.021 | 0.640 ± 0.080 | 1.037 |
| 150 | 0.975 ± 0.135 | 1.347 ± 0.150 | 2.322 |
| 180 | 1.724 ± 0.461 | 2.334 ± 0.282 | 4.058 |
| 210 | 2.982 ± 0.150 | 3.953 ± 0.041 | 6.935 |
| 240 | 4.523 ± 0.051 | 5.765 ± 0. 650 | 10.288 |
| 270 | 6.372 ± 1.150 | 7.527 ± 0.042 | 13.899 |
| 300 | 8.629 ± 1.642 | 9.356 ± 1.325 | 17.985 |
| 330 | 7.865 ± 0.683 | 10.437 ± 0.860 | 18.302 |
| 360 | 7.247 ± 0.914 | 10.974 ± 1.631 | 18.221 |

± = Standard Error

**Table 5.3 :** Effect of potassium on oven dry biomass (g/plant) of *Crinum defixum*

| Age of plant (days) | Biomass | | |
|---|---|---|---|
| | Leaf | Bulb with Root | Total |
| 90 | 0.014 ± 0.005 | 0.031 ± 0.002 | 0.045 |
| 120 | 0.029 ± 0.006 | 0.064 ± 0.009 | 0.093 |
| 150 | 0.075 ± 0.003 | 0.152 ± 0.007 | 0.237 |
| 180 | 0.364 ± 0.008 | 0.678 ± 0.005 | 1.042 |
| 210 | 1.231 ± 0.105 | 1.958 ± 0.082 | 3.179 |
| 240 | 2.175 ± 0.840 | 3.495 ± 0.573 | 5.670 |
| 270 | 3.136 ± 1.620 | 5.273 ± 0.098 | 8.409 |
| 300 | 3.985 ± 1.782 | 6.588 ± 0.315 | 10.574 |
| 330 | 3.235 ± 1.067 | 7.523 ± 1.162 | 10.758 |
| 360 | 2.956 ± 0.810 | 6.972 ± 0.957 | 9.928 |

± = Standard Error

**Table 5.4 :** Effect of nitrogen, phosphorus and potassium on net primary productivity (g/plant/day) of *Crinum defixum*

| Age of plant (days) | Net Primary Productivity | | |
|---|---|---|---|
| | Nitrogen | Phosphorus | Potassium |
| 90 | - | - | - |
| 120 | 0.002 | 0.030 | 0.002 |
| 150 | 0.017 | 0-.042 | 0.005 |
| 180 | 0.041 | 0.057 | 0.053 |
| 210 | 0,086 | 0.095 | 0.071 |
| 240 | 0.101 | 0.112 | 0.079 |
| 270 | 0.118 | 0.120 | 0.095 |
| 300 | 0.038 | 0.136 | 0.072 |
| 330 | 0.026 | 0.011 | 0.006 |
| 360 | -0.016 | -0.002 | -0.027 |

**Table 5.5 :** Effect of nitrogen, phosphorus and potassium on the percentage contribution of the plant parts to the total plant

| Age of plant (days) | Nitrogen | | Phosphorus | | Potassium | |
|---|---|---|---|---|---|---|
| | Leaf | Bulb + Root | Leaf | Bulb + Root | Leaf | Bulb + Root |
| 90 | 31.168 | 68.831 | 37.272 | 62.72 | 31.111 | 68.888 |
| 120 | 34.848 | 65.151 | 38.283 | 61.716 | 31.182 | 68.817 |
| 150 | 35.593 | 64.406 | 41.989 | 59.010 | 31.645 | 64,135 |
| 180 | 36.563 | 58.083 | 42.483 | 57.516 | 34.932 | 67.067 |
| 210 | 37.965 | 62.034 | 42.999 | 57.001 | 38.723 | 61.591 |
| 240 | 39.167 | 60.832 | 43. 963 | 56.036 | 38.359 | 61.642 |
| 270 | 39.431 | 60.568 | 45.845 | 54.155 | 37.293 | 62.700 |
| 300 | 39.908 | 60.092 | 47.978 | 52.021 | 37.686 | 62.304 |
| 330 | 32.947 | 67.052 | 42.973 | 57.026 | 30.070 | 69.929 |
| 360 | 28.347 | 71.650 | 39.772 | 60.227 | 29.774 | 70.225 |

indicates that the dry weight of leaves is highest in phosphorus treatment followed by nitrogen and potassium treatments, respectively. The increase in leaf weight is up to 300 days after which it declined. Like that of leaves the standing biomass of bulb including root is highest in case of phosphorus treatment followed by nitrogen and potassium. Figure 5.1, 5.2 and 5.3, Table 5.1, 5.2 and 5.3 shows the effect of nitrogen, phosphorus and potassium on oven dry biomass.

Figure 5.4 shows the effect of nitrogen, phosphorus and potassium on total biomass of the plant at different age group.

The net primary production of whole plant (g/plant/day) increases with the increase in age of plant upto the period varying from 270-300 days depending upon treatment. At every stage of growth it is highest in case of phosphorus treatment. The nitrogen and potassium treated plants stand second and third respectively (Table 5.4 and Figure 5.5). The changes in the percentage contribution of leaf and bulb including root have been calculated. There was continuous increase in percentage dry weight of leaf and found to be highest in case of phosphorus treated followed by nitrogen and potassium treated plants (Table 5.5).

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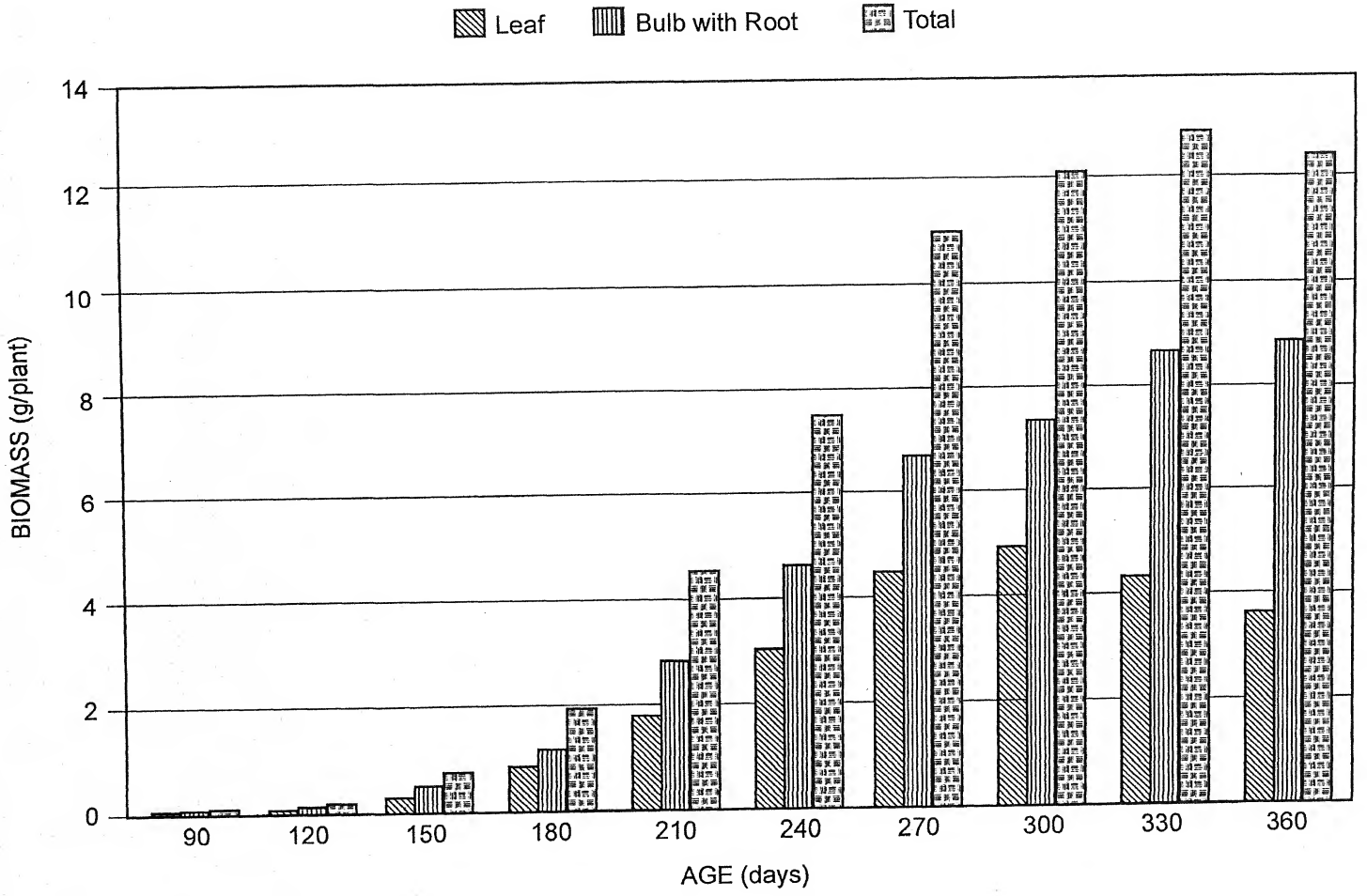


Fig. 5.1 : Effect of nitrogen on biomass (g/plant) of *Crinum defixum*

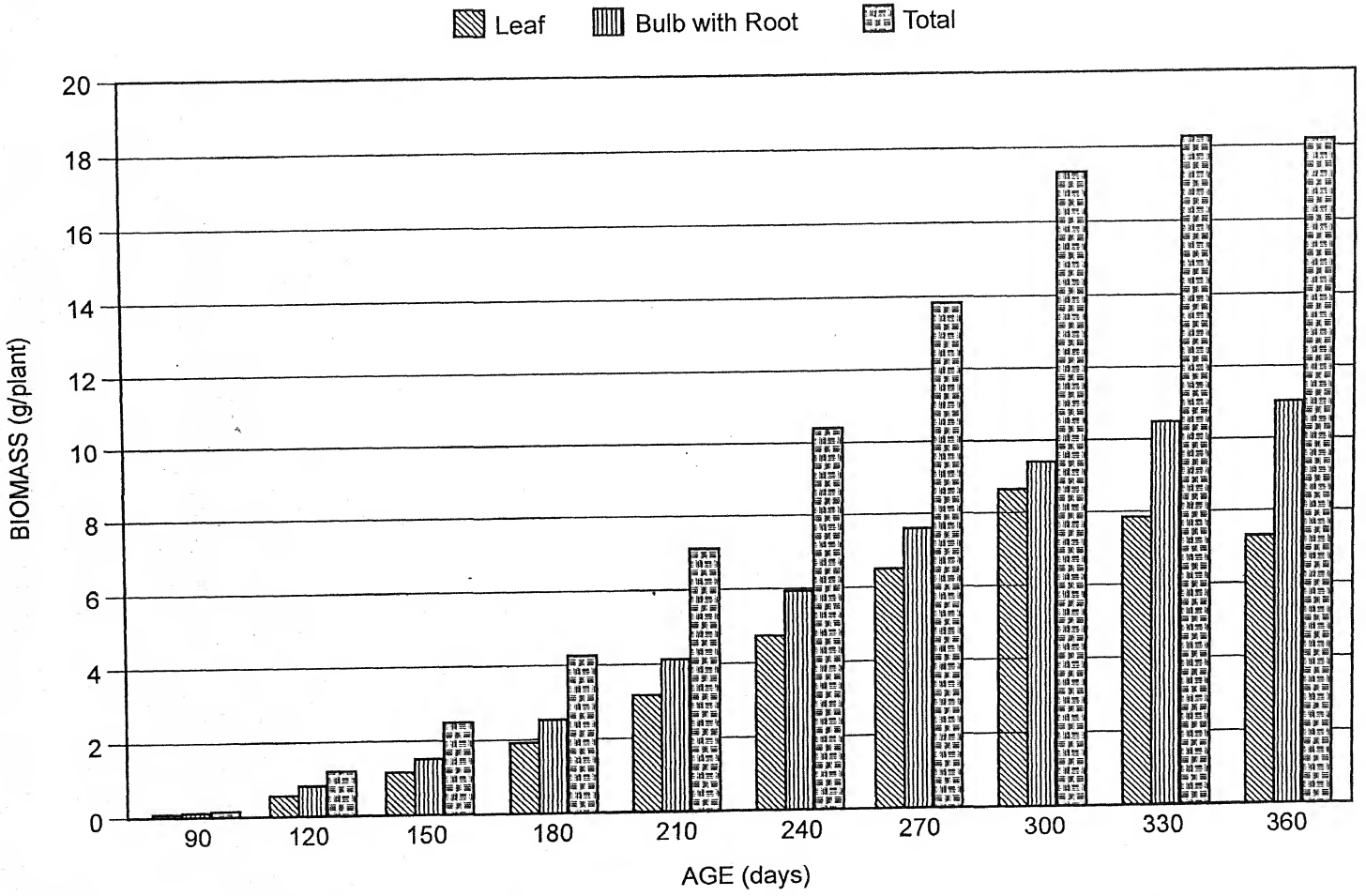


Fig. 5.2 : Effect of Phosphorus on oven dry biomass (g/plant) of *Crinum defixum*

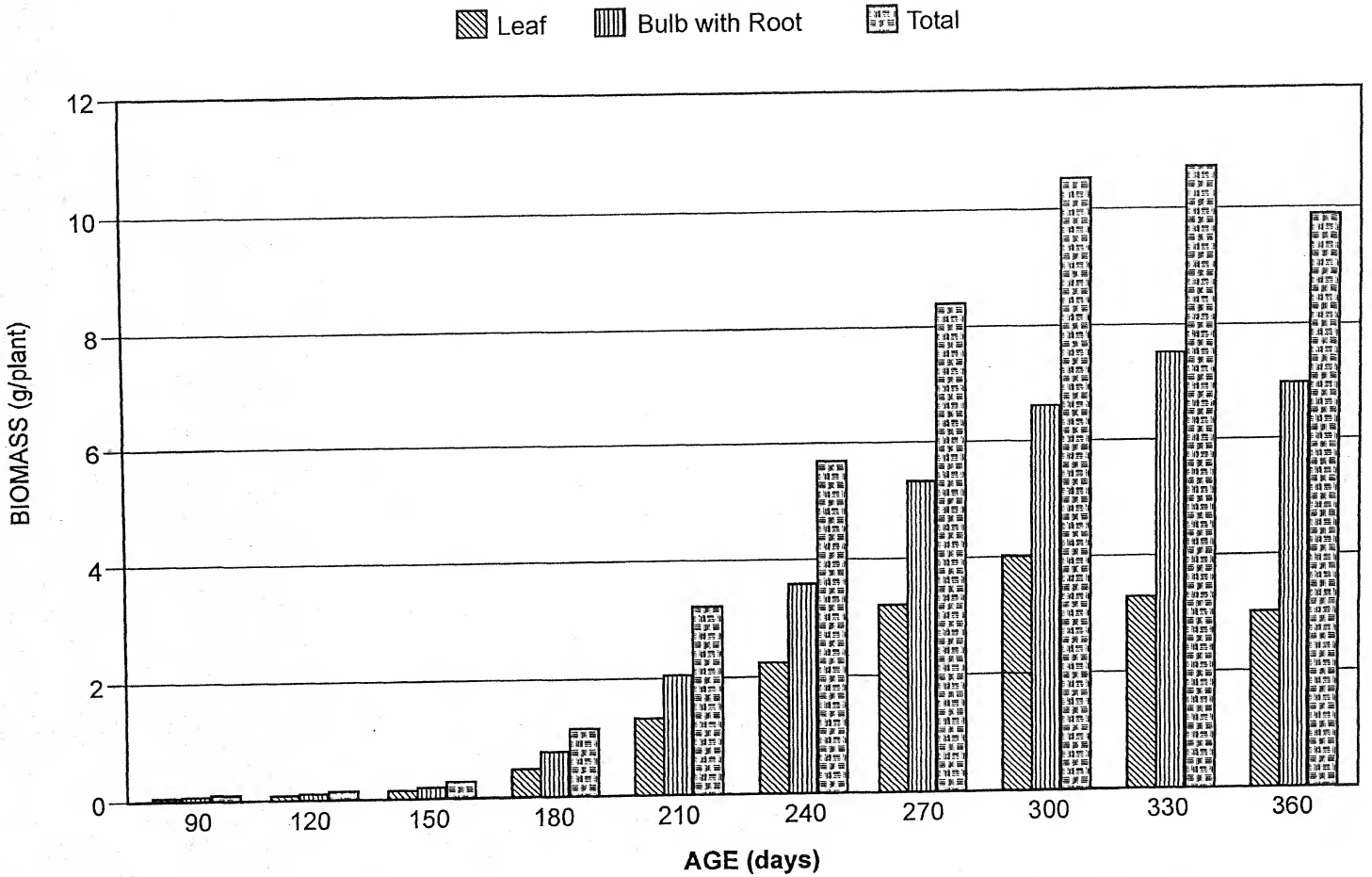


Fig. 5.3 : Effect of potassium on oven dry biomass (g/plant) of *Crinum defixum*

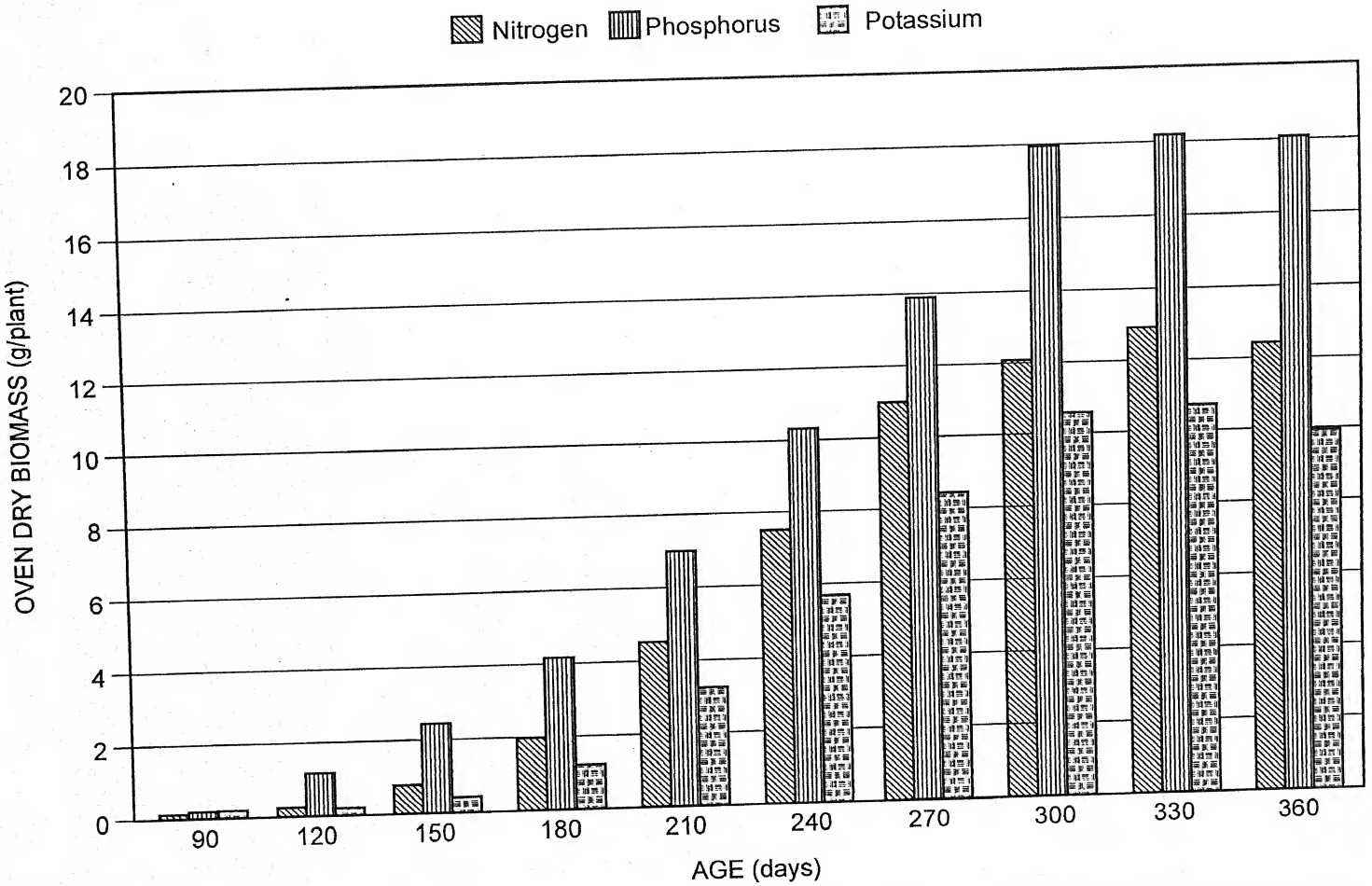


Fig. 5.4 : Effect of nitrogen, phosphorus and potassium on total biomass (g/plant) of *Crinum defixum*

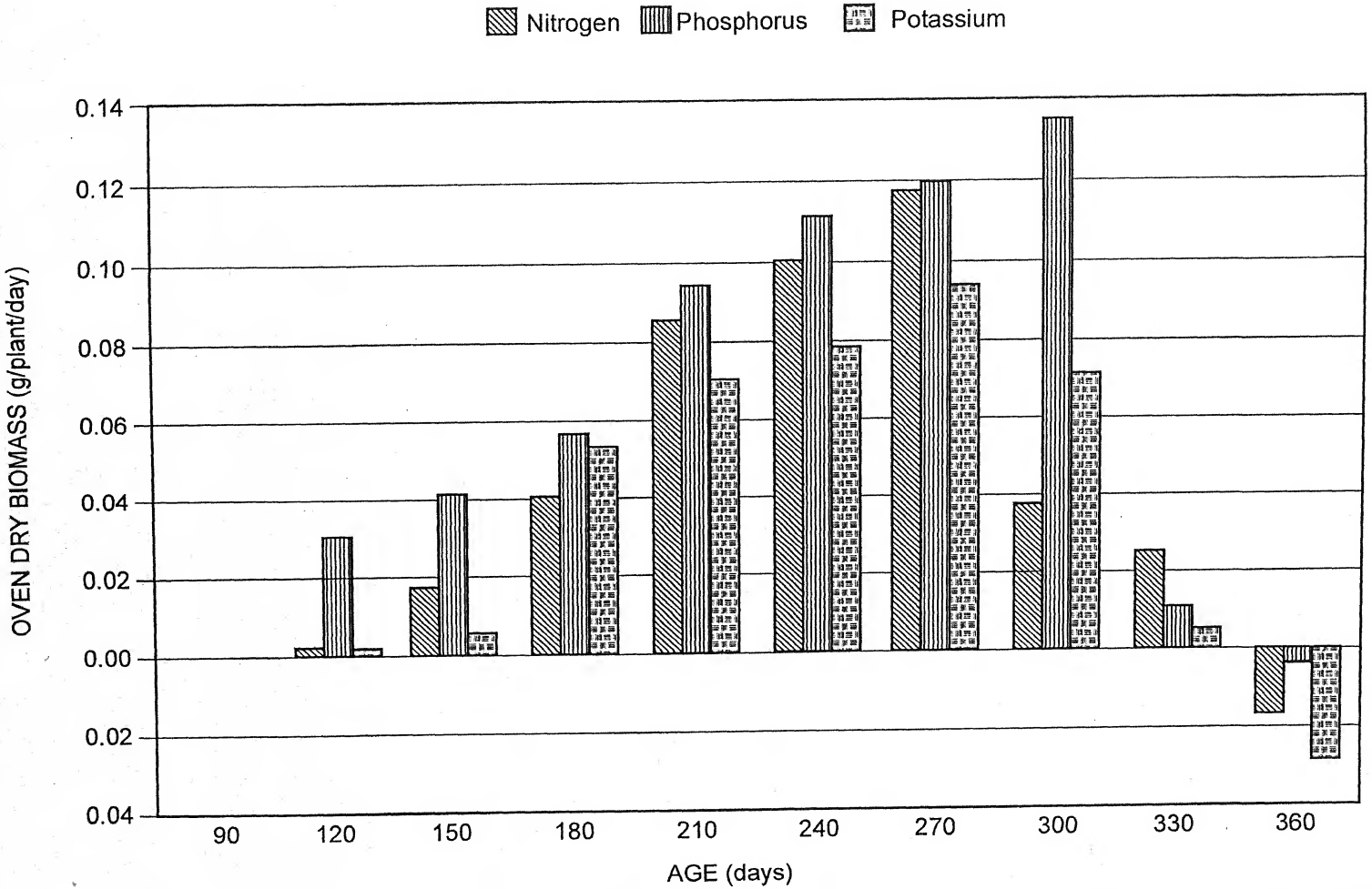


Fig. 5.5 : Effect of nitrogen, phosphorus and potassium on net primary productivity (g/plant/day) of *Crinum defixum*

# CHAPTER - VI

# PHOTOPERIODIC APPLICATION

## PHOTOPERIOD APPLICATION

In contrast to most other seasonal factors, day length is always the same for a given season and locality. The amplitude in the annual cycle increases with increasing latitude, thus providing latitudinal as well as seasonal causes. Photoperiod has been shown to be the timer or trigger that sets off physiological sequences which bring about growth and flowering of many plants. Among the higher plants some species bloom on increasing day length and are called long-day plants, while others that bloom on short days are known as short-day plant.

It has been shown that the number of underground nitrogen-fixing root nodules on legumes is controlled by photoperiod acting through the leaves of the plant. Since nitrogen-fixing bacteria in the nodules require food energy manufactured by the plant leaves to do their work, the more light and chlorophyll, the more food becomes available to the bacteria, the maximum coordination between the plant and its microbial partners is thus enhanced by the photoperiod regulator. Intensity of light impinging on the autotrophic layer controls the entire ecosystem through its influence on primary

production. The relationship of intensity to photosynthesis in both terrestrial and aquatic plants follows the same general pattern of linear increase up to an optimum or light saturation level followed by instances by the decreases at very high intensities.

The photoperiod is of great significance because it determine the flowering and seed setting in a large number of plant species and the interaction with other factors like temperature determines their distribution. Kaul (1959) established two ecological races of *Xanthium strumarium*, Tiagi and Trivedi (1978) in *Utricularia inflexa* var. *stellaris* which behaved differently with light period. Lalman (1976) studied the photoperiod effect on the growth of *Neptha ruderalis*.

## MATERIALS AND METHODS

Mature bulb of the plant having same size (4 cm in dia) were collected and germinated for seedlings in sandy loam soil under shade of a tree. After germination each seedling was transplanted in earthen pot of 30 cm diameter, filled with loamy soil at three leaved stage. Only one plant was ultimately grown in each pot and three replicates were harvested at a time. Light proof boxes having few side pores for exchange of gases were used to control the photoperiods. The experiment was conducted for five sets of photoperiods as follows :

(A) 4 hrs light and 20 hrs darkness,

(B) 6 hrs light and 18 hrs darkness,

(C) 8 hrs light and 16 hrs darkness,

(D) 10 hrs light and 14 hrs darkness and

(E) 12 hrs light and 12 hrs darkness.

Observations were taken by digging out the whole plant from the pot at different time of interval. The different plant parts were separated, dried in oven at $80^0$C for 48 hrs and weighed for biomass determination. The production was calculated from monthly difference in dry weight.

## RESULTS

The standing dry weight is greater in case of 6 hrs light. It decreases with increase of light period. Total biomass of aboveground and underground parts is highest in 6 hrs light which declined afterwards. The standing crop biomass of plant treated with 12 hrs light period was remarkably less (Table 6.1 and Figure 6.1). The net primary productivity (g/plant/day) increased with advance age of plant. It showed highest value in case of 270-300 days old plant, followed by decrease thereafter. The productivity was highest in case of 6 hrs light period and lowest in 12 hrs light (Table 6.2 and Figure 6.2). There was not a remarkable difference in 6 hrs and 8

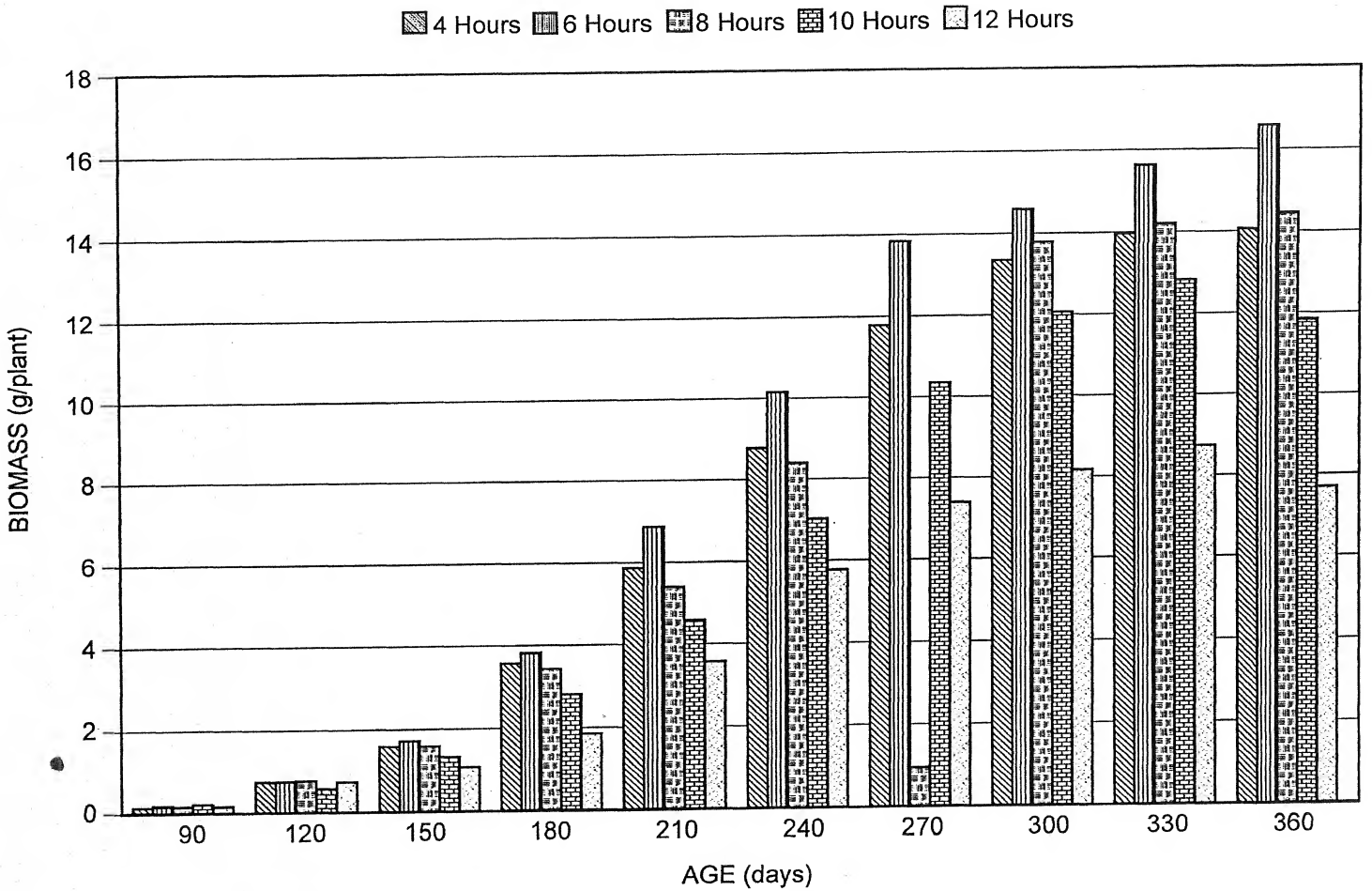


Fig. 6.1 : Effect of different photoperiods on biomass (g/plant) of *Crinum defixum* in relation to age

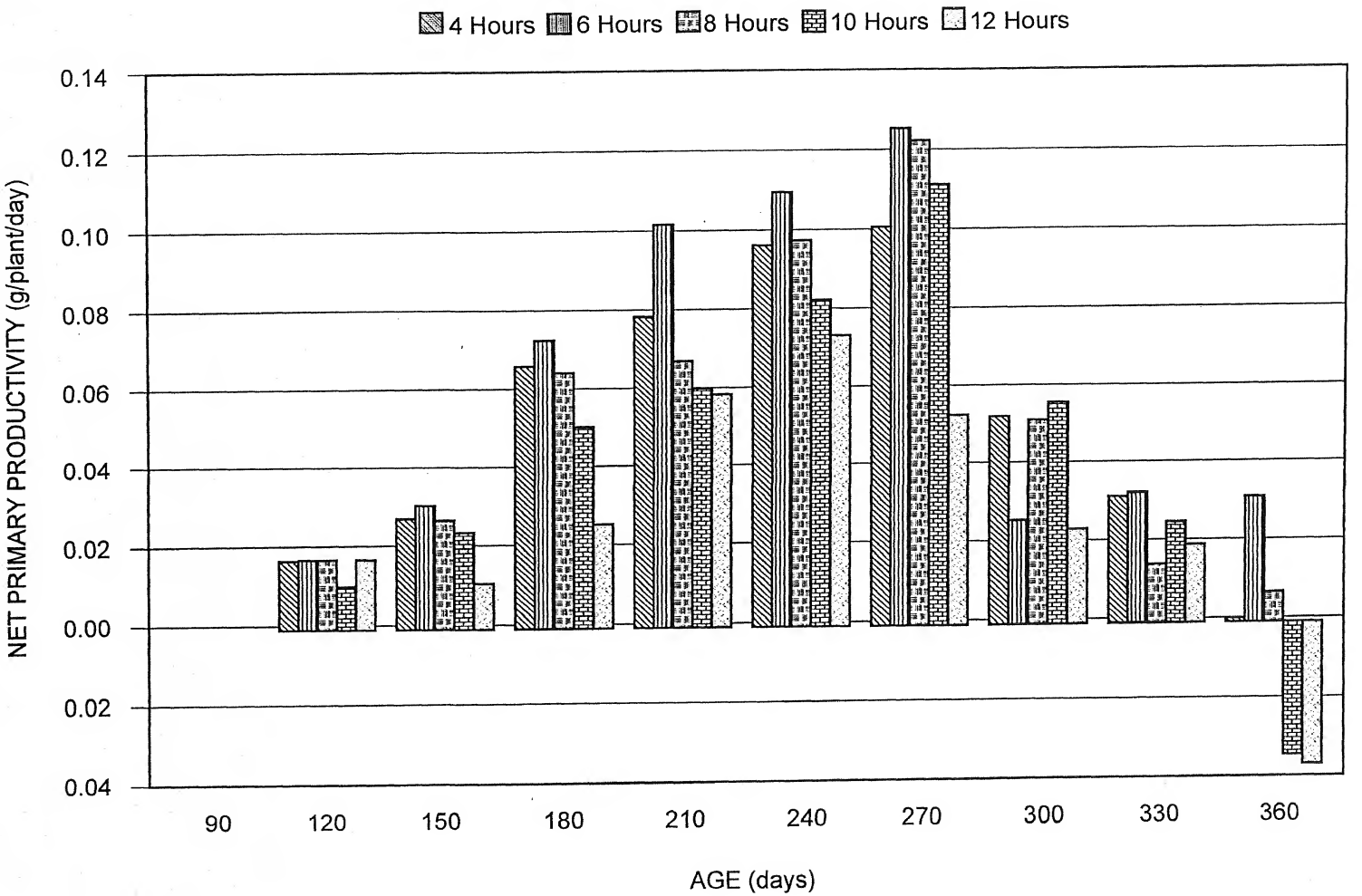


Fig. 6.2 : Net primary productivity (g/plant/day) at different photoperiods of *Crinum defixum*

**Table 6.1** : Effect of different photoperiods on biomass (g/plant) of *C.defixum* in relation to age

| Age of plant (Days) | Photoperiod (hrs) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | | | 6 | | | 8 | | | 10 | | | 12 | | |
| | Above-ground Leaf | Under-ground Bul.+ Root | Total | Above-ground Leaf | Under-ground Bul.+ Root | Total | Above-ground Leaf | Under-ground Bul.+ Root | Total | Above-ground Leaf | Under-ground Bul.+ Root | Total | Above-ground Leaf | Under-ground Bul.+ Root | Total |
| 90 | 0.057 ± 0.006 | 0.072 ± 0.008 | 0.129 | 0.059 ± 0.007 | 0.078 ± 0.005 | 0.131 | 0.057 ± 0.001 | 0.072 ± 0.015 | 0.129 | 0.039 ± 0.004 | 0.074 ± 0.009 | 0.113 | 0.035 ± 0.004 | 0.071 ± 0.008 | 0.106 |
| 120 | 0.237 ± 0.004 | 0.413 ± 0.023 | 0.650 | 0.236 ± 0.020 | 0.425 ± 0.012 | 0.661 | 0.191 ± 0.002 | 0.453 ± 0.009 | 0.664 | 0.157 ± 0.019 | 0.294 ± 0.023 | 0.451 | 0.207 ± 0.017 | 0.429 ± 0.006 | 0.636 |
| 150 | 0.617 ± 0.020 | 0.895 ± 0.017 | 1.512 | 0.649 ± 0.077 | 0.951 ± 0.115 | 1.600 | 0.602 ± 0.051 | 0.851 ± 0.102 | 1.453 | 0.421 ± 0.050 | 0.751 ± 0.090 | 1.172 | 0.332 ± 0.039 | 0.645 ± 0.077 | 0.947 |
| 180 | 1.610 ± 0.032 | 1.936 ± 0.042 | 3.546 | 1.650 ± 0.033 | 2.251 ± 0.045 | 3.801 | 1.231 ± 0.024 | 2.186 ± 0.043 | 3.417 | 0.905 +0.026 | 1.815 ± 0.017 | 2.720 | 0.618 ± 0.015 | 1.157 ± 0.061 | 1.773 |
| 210 | 2.784 ± 0.306 | 3.143 ± 0.094 | 5.927 | 3.152 ± 0.094 | 3.725 ± 0.409 | 6.877 | 2.517 ± 0.050 | 2.915 ± 0.058 | 5.432 | 1.761 ± 0.053 | 2.762 ± 0.331 | 4.523 | 1.306 ± 0.054 | 2.264 ± 0.271 | 3.570 |
| 240 | 4.270 ± 0.128 | 4.582 ± 0.504 | 8.852 | 4.975 ± 0.547 | 5.207 ± 0.572 | 10.182 | 4.020 ± 0.120 | 4.352 ± 0.120 | 8.372 | 3.105 ± 0.093 | 3.935 ± 0.119 | 7.040 | 2.553 ± 0.076 | 3.252 ± 0.097 | 5.805 |
| 270 | 5.702 ± 0.627 | 6.178 ± 0.185 | 11.880 | 6.558 ± 0.196 | 7.412 ± 0.196 | 13.970 | 5.405 ± 0.594 | 6.940 ± 0.763 | 12.345 | 4.486 ± 0.134 | 5.927 ± 0.651 | 10.413 | 2.916 ± 0.320 | 4.510 ± 0.541 | 7.426 |
| 300 | 6.251 ± 0.187 | 7.2151 ± 0.793 | 3.466 | 6.924 ± 0.830 | 7.852 ± 0.235 | 14.776 | 6.718 ± 0.201 | 7.182 ± 0.215 | 13.900 | 5.207 +0.572 | 6.921 ± 0.207 | 12.128 | 3.107 ± 0.093 | 5.053 ± 0.151 | 8.160 |
| 330 | 6.510 ± 0.195 | 7.647 ± 0.917 | 14.157 | 7.257 ± 0.798 | 8.550 ± 0.940 | 15.807 | 6.104 ± 0.671 | 8. 23 5 ± 0.671 | 14.339 | 5.492 ± 0.164 | 7.421 ± 0.816 | 12.913 | 3.160 ± 0.094 | 5.601 ± 0.616 | 8.761 |
| 360 | 6.152 ± 0.676 | 8.056 ± 0.242 | 14.208 | 7.330 ± 0.219 | 9.475 ± 1.137 | 16.805 | 6.073 ± 0.152 | 8.527 ± 0.152 | 14.600 | 4.307 ± 0.473 | 7.630 ± 0.228 | 11.937 | 2.481 ± 0.053 | 5.256 ± 0.157 | 7.737 |

± = Standard error

**Table 6.2 :** Net primary productivity (g/plant/day) at different photoperiods of *Crinum defixum*

| Age of plant | Photoperiod (hrs) | | | | |
|---|---|---|---|---|---|
| (Days) | 4 | 6 | 8 | 10 | 12 |
| 90 | - | - | - | - | - |
| 120 | 0.017 | 0.017 | 0.017 | 0.011 | 0.018 |
| 150 | 0.028 | 0.031 | 0.027 | 0.024 | 0.011 |
| 180 | 0.067 | 0.073 | 0.065 | 0.051 | 0.026 |
| 210 | 0.079 | 0.102 | 0.067 | 0.060 | 0.059 |
| 240 | 0.097 | 0.110 | 0.098 | 0.083 | 0.074 |
| 270 | 0.101 | 0.126 | 0.123 | 0.112 | 0.054 |
| 300 | 0.053 | 0.026 | 0.052 | 0.057 | 0.024 |
| 330 | 0.033 | 0.034 | 0.015 | 0.026 | 0.020 |
| 360 | 0.001 | 0.033 | 0.008 | -0.032 | -0.034 |

**Table 6.3 :** Percentage contribution of plant parts to the total plant of *Crinum defixum* at different potoperiods

| Age of the plant (Days) | Photoperiods (hrs) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | | 6 | | 8 | | 10 | | 12 | |
| | Above-ground | Under-ground | Above-ground | Under-ground | Above-ground | Under-ground | Above-ground | Under-ground | Above-ground | Under-ground |
| | Leaf | Bul.+Root | Leaf | Bul.+Root | Leaf | Bul.+Root | Leaf | Bul.+Root | Leaf | Bul.+Root |
| 90 | 44.186 | 55.813 | 43.066 | 56.934 | 44.186 | 55.814 | 34.513 | 65.487 | 33.018 | 66.981 |
| 120 | 36.462 | 63.538 | 35.251 | 64.297 | 29.728 | 70.341 | 34.812 | 65.188 | 32.547 | 67.450 |
| 150 | 40.807 | 59.193 | 40.563 | 59-437 | 41.432 | 58.568 | 35.922 | 64.078 | 33.981 | 66.018 |
| 180 | 45.403 | 54.967 | 43.401 | 59.220 | 36.026 | 63.974 | 33.270 | 66.727 | 34.743 | 65.256 |
| 210 | 46.971 | 53.024 | 45.833 | 54.166 | 46.337 | 53.663 | 38.934 | 61.065 | 36.582 | 63.417 |
| 240 | 48.238 | 51.762 | 48.861 | 51.139 | 4 8.017 | 51.982 | 44.105 | 55.894 | 43.979 | 56.020 |
| 270 | 47.996 | 52.003 | 46.943 | 53.056 | 43.782 | 56.217 | 43.080 | 56.919 | 39.267 | 60.732 |
| 300 | 46.421 | 53.579 | 46.859 | 53.140 | 48.330 | 51.669 | 42.933 | 57.066 | 38.075 | 61.924 |
| 330 | 45.984 | 54.016 | 45.910 | 54.089 | 42.569 | 57.431 | 42.530 | 57.469 | 36.068 | 63.931 |
| 360 | 43.299 | 56.700 | 43.617 | 56. 382 | 41.698 | 58.302 | 36.081 | 63.918 | 32.066 | 67.933 |

hrs light period on the biomass as well as primary productivity but little difference was obtained.

There was considerable difference in percentage contribution of main parts of plant in relation to time, in different photoperiods. The percentage contribution of leaf is higher in shorter duration of light at every stage of growth. It declined in plant treated with longer period and lowest value was recorded in case of 12 hrs. The percentage dry weight of bulb and root increased with age of plant attaining the highest value at the time of harvesting i.e. 360 days (Table 6.3).

The increment of biomass with advancing age of *Crinum defixum* gives an usual sigmoid curve and the total dry matter production differs with respect to light period. Best growth took place in 6 hrs to 8 hrs photoperiod beyond which it is favourable for reproductive growth.

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# CHAPTER - VII

# STANDING CROP BIOMASS AND PRIMARY PRODUCTIVITY

# STANDING CROP BIOMASS AND PRIMARY PRODUCTIVITY

Primary productivity of an ecological system is defined as the rate at which radiant energy is stored by photosynthesis and chemosynthesis (which is negligible) of producer organisms (mainly green plants) in the form of organic substances which can be used a food materials. Primary productivity studies have assumed increasing significance during the last four decades even since the operative phase of the International Biological Programme began in 1967. Sustenance of life on earth ultimately depends on that fractions of solar energy which gets converted into stored energy of organic matter produced in plants. The amount of biomass produced or energy stored in the plant body in any ecosystem is referred to as primary productivity. Estimation of biomass is essential in determining the status and flux of biological material in ecosystem and necessary to understand the dynamics of these ecosystem. Standing-crop biomass gives only the static picture of ecosystem providing an estimate of the organic matter that is present per unit area at a particular time. Dynamic picture of a ecosystem can be drawn only by estimating the changes in biomass at short interval over a period of time in order to study the functional aspect.

The total weight of plant dry matter present in ecosystem at the any time accounts for the biomass. The organic matter input to an ecosystem by the autotrophs during a given period of time is a measure of rate of primary production. Gross primary productivity (GPP) is the total conversion through photosynthesis, while the net primary production (NPP) is the amount of gross production remaining after autotrophic respiration but including all attributed to litter fall, biotic interference and fruiting. Net primary production is most commonly measured as dry organic matter synthesized per unit area per unit time and is usually expressed as $g/m^2/day$.

The importance of primary production of different plant communities has been stressed by the activities of the International Biological Programme and Man and Biosphere Programme. NPP and related problems on global basis have been made by Bray *et al.* (1959), Weigert and Evans (1964), Golley (1972), Lieth (1962, 72, 73, 75), Lieth and Whittaker (1975). Notable contribution to production ecology of cultivated crops have been made by Marwah (1972), Iwaki (1974), Pesternak (1974), Singh (1974), Khokhar and Pandey (1976), Dhingra (1978), Nath and Gupta (1981), Kumar (1984), Pandey and Nath (1990), Pandey and Vihari (1991), Pandey and Kumari (1992), Pandey and Sinha, (1994), Pandey and Kumari (1995).

This chapter deals with the standing crop biomass and primary productivity of the medicinal plant i.e. *Crinum defixum*.

## RESULTS

### Standing Crop Biomass

The standing crop biomass of different parts of *Crinum defixum* has been studied and the biomass values are shown in the Table 7.1 and Figure 7. 1.

### Aboveground Biomass

**Standing live biomass :**

The mean total biomass at 30 days of growth was found to be 5.71 g/m$^2$ which increased gradually up to 62.25 g/m$^2$ at 270 days and thereafter there was decrease in the biomass value i.e. 42.78 g/m$^2$ at the age of 360 days (Table 7.1 and Figure 7.1).

**Standing dead biomass :**

The standing dead biomass in the form of dried plant parts i.e. yellow leaves appeared between 210 and 360 days. It was found 4.02 g/m$^2$ at the age of 210 days which increased to 44.78 g/m$^2$ at 360 days of growth period (Table 7.1 and Figure 7.1).

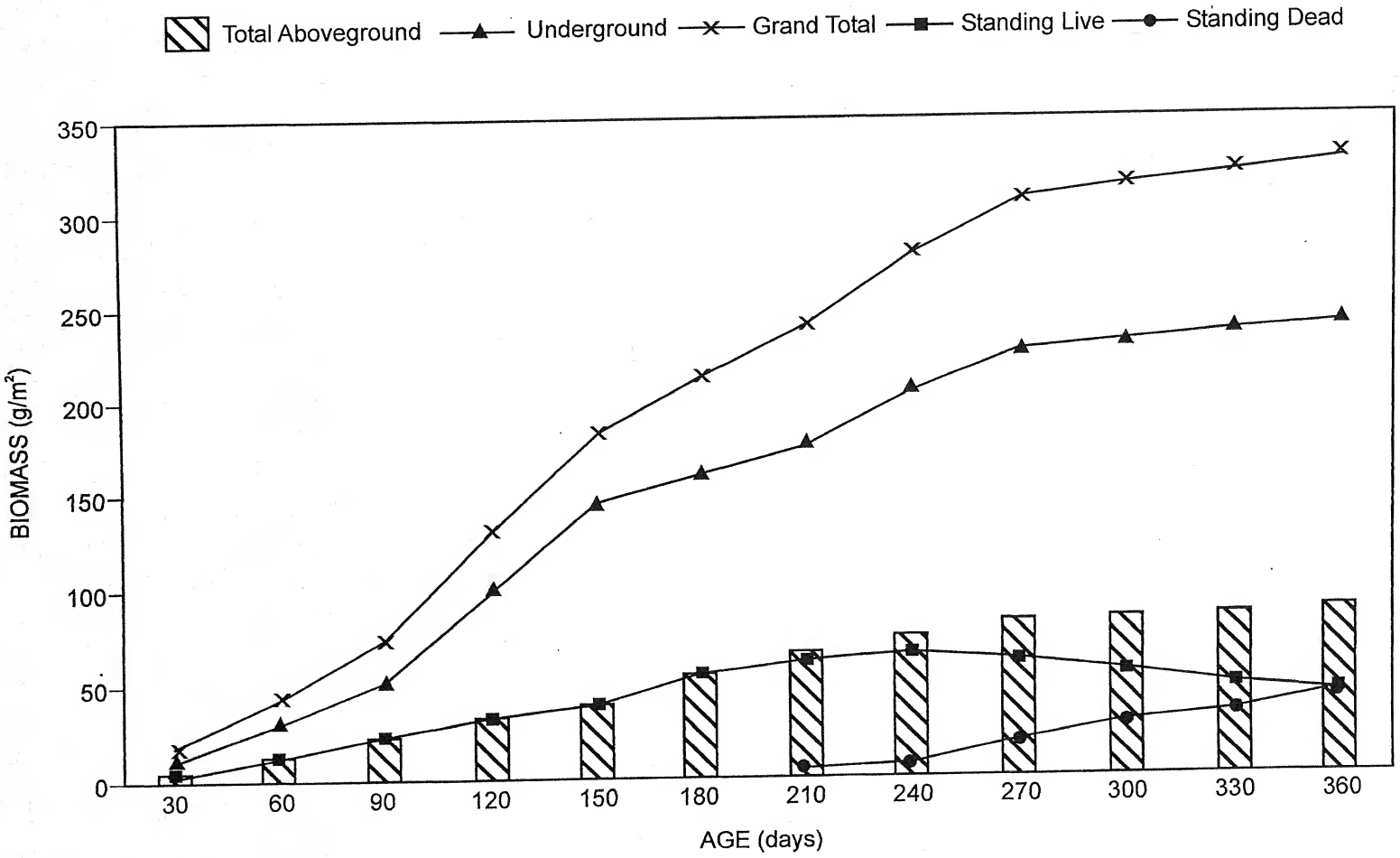


Fig. 7.1 : Mean standing crop biomass ($g/m^2$) of *Crinum defixum* in different age group

**Table 7.1 :** Mean standing crop biomass ($g/m^2$) of *Crinum defixum* in different age group

| Age (Days) | Aboveground | | | Underground | Total |
|---|---|---|---|---|---|
| | Standing live | Standing dead | Total | Bulb + Root | |
| 30 | 5.71 ± 0.74 | - | 5.71 ± 0.74 | 14.06 ± 1.26 | 19.77 ±1.95 |
| 60 | 13.26 ± 1.59 | - | 13.26 ± 1.59 | 32.17 ± 2.89 | 45.43 ± 5.45 |
| 90 | 22.73 ± 3.18 | - | 22.73 ± 3.78 | 51.15 ± 4.60 | 73.88 ± 8.12 |
| 120 | 31.89 ± 2.87 | - | 31.89 ± 2.87 | 98.99 ± 12.86 | 130.88 ± 11.77 |
| 150 | 38.42 ± 4.99 | - | 38.42 ±.4.22 | 143.53 ± 12.91 | 181.95 ± 21.83 |
| 180 | 53.22 ± 6.38 | - | 53.22 ± 6.38 | 159.16 ± 20.68 | 212.38 ± 23.36 |
| 210 | 60.51 ± 6.89 | 4.02 ± 0.36 | 64.53 ± 5.80 | 175.24 ± 21.02 | 239.77 ± 21.57 |
| 240 | 65.63 ± 6.80 | 7.64 ± 0.91 | 74.27 ± 8.16 | 204.29 ± 28.60 | 278.56 ± 30.64 |
| 270 | 62.25 ± 7.47 | 18.64 ± 2.23 | 80.79 ± 9.69 | 225.75 ± 27.99 | 306.54 ± 27.58 |
| 300 | 55.64 ± 6.67 | 27.72 ± 2.49 | 83.36 ± 7.50 | 230.54 ± 26.34 | 313.90 ± 37.66 |
| 330 | 49.18 ± 4.42 | 35.17 ± 4.22' | 84.35 ± 9.27 | 235.86 ± 18.97 | 320.21 ± 35.22 |
| 360 | 42.78 ± 5.13 | 44.78 ± 4.03 | 87.56 ± 7.88 | 240.63 ± 24.73 | 328.19 ± 36. 10 |

± = Standard error

## Underground Biomass

It was found to be 14.06 g/m$^2$ in 30 days and it has increased to 240 g/m$^2$ in 360 days of growth (Table 7.1 and Figure 7.1).

## Percent Contribution of Plant Parts

The percent contribution of each part i.e. aboveground (standing live and standing dead) and underground (Bulb and root) to the total plant biomass of *Crinum defixum* has been presented in Table 7.2 and Figure 7.2.

The percentage contribution of aboveground standing live to total biomass was 28.88% in 30 days which had increased to 30.77% in 90 days and thereafter decreased to 13.04% in 360 days of growth period (Table 7.2).

Biomass contribution by aboveground standing dead to the total biomass was minimum 1.67% in 210 days and maximum i.e. 13.64% in 360 days of growth (Table 7.2).

The present contribution by underground part to total biomass in 30 days of growth was 71.12% which thereafter increased to 73.66% in 330 days (Table 7.2).

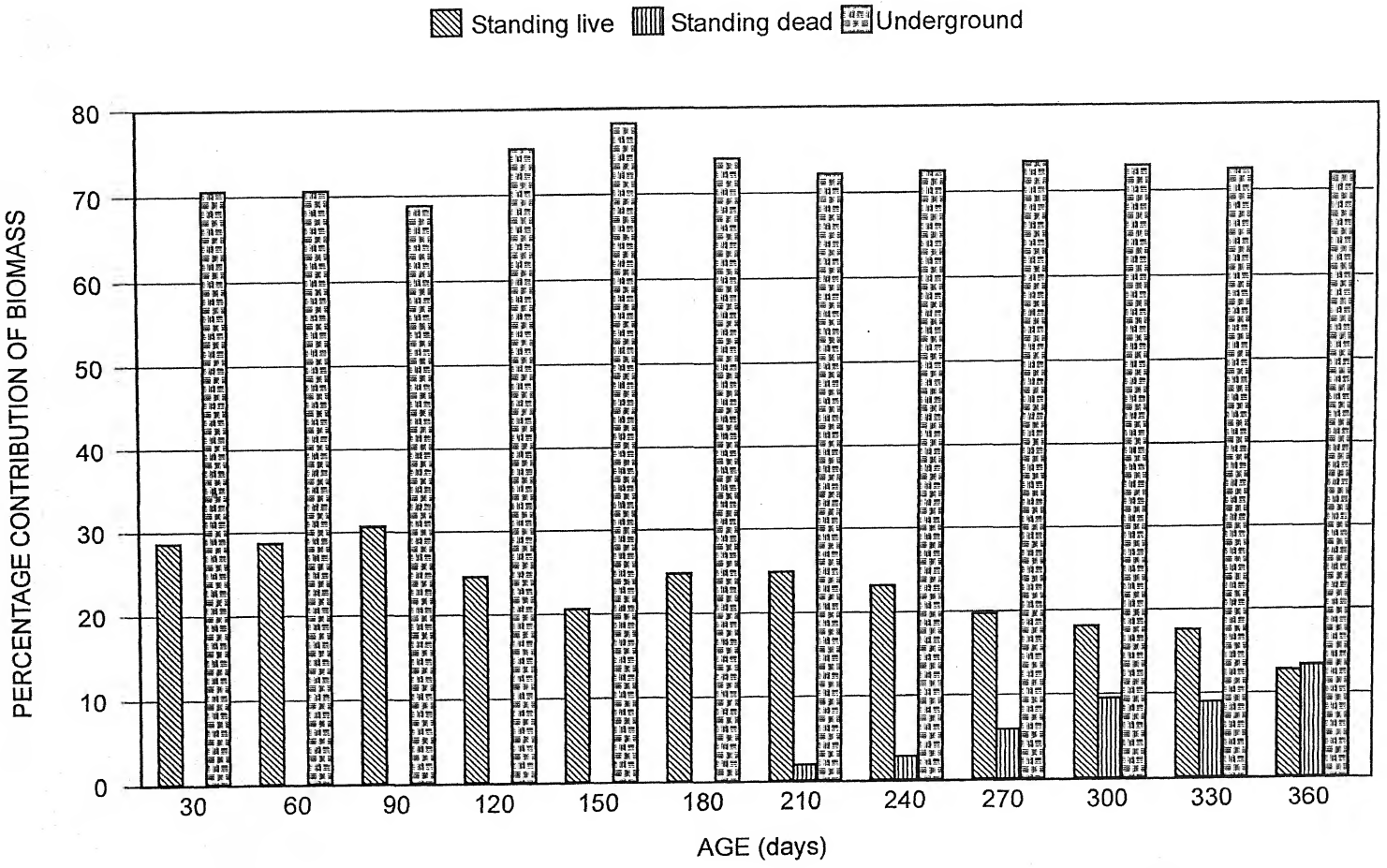


Fig. 7.2 : Percentage contribution of plant parts to the total plant of *Crinum defixum*

**Table 7.2 :** Percentage contribution of plants part to the total plant of *Crinum defixum*

| Age (Days) | Aboveground | | Underground |
|---|---|---|---|
| | Standing live | Standing dead | |
| 30 | 28.88 | - | 71.12 |
| 60 | 29.19 | - | 70.81 |
| 90 | 30.77 | - | 69.23 |
| 120 | 24.89 | - | 75.63 |
| 150 | 21.12 | - | 78.88 |
| 180 | 25.09 | - | 74.94 |
| 210 | 25.24 | 1.67 | 73.09 |
| 240 | 23.56 | 2.74 | 73.34 |
| 270 | 20.25 | 6.08 | 73.64 |
| 300 | 17.72 | 8.83 | 73.44 |
| 330 | 17.37 | 8.66 | 73.66 |
| 360 | 13.04 | 13.64 | 73.32 |

## Mean and Current Increment in Biomass

The mean and current increment in total plant biomass was observed in *Crinum defixum* (Table 7.3).

The mean increment in total plant biomass followed an increasing trend i.e. 0.19 g/m$^2$/day to 0.31 g/m$^2$/day between 30 and 240 days and thereafter it has decreased to 0.24 g/m$^2$/day at 360 days of growth in aboveground part of *Crinum defixum.* The mean increasing rate in underground part of *Crinum defixum* was 0.47 g/ m$^2$/day at 30 days of growth which followed an increasing trend reaching to a maximum of 0.97 g/m$^2$/day at 150 days which latter on decreased to 0.67 g/m$^2$/day of growth (Table 7.3).

The current increment rate of total plant biomass in aboveground part of *Crinum defixum* followed an increasing trend i.e. from 0.25 g/m$^2$/day to 0.49 g/m$^2$/day between 30 and 180 days which later on decreased to 0.12 g/m$^2$/day at 360 days. The current increment rate of underground biomass ranged from 0.60 g/m$^2$/day to 1.59 g/m$^2$/day between 60 and 120 days. Thereafter, it has decreased to 0.16 g/m$^2$/day at 360 days of growth (Table 7.3).

**Net Primary Productivity :**

Net primary productivity of aboveground (standing live and standing dead) and underground (Bulb + root) parts of *Crinum defixum* grown for the period of 360 days has been presented in Table 7.4.

**Table 7.3 :** Total plant biomass, mean and current increment in aboveground and underground biomass of *Crinum defixum*

| Age (Days) | Total biomass ($g/m^2$) | | Mean increment ($g/m^2/day$) | | Current increment ($g/m^2/day$) | |
|---|---|---|---|---|---|---|
| | Above-ground | Under-ground | Above-ground | Under-ground | Above-ground | Under-ground |
| 30 | 5.71 | 14.06 | 0.19 | 0.47 | - | - |
| 60 | 13.26 | 32.17 | 0.22 | 0.54 | 0.25 | 0.60 |
| 90 | 22.73 | 51.15 | 0.25 | 0.57 | 0.31 | 0.63 |
| 120 | 31.89 | 98.99 | 0.27 | 0.82 | 0.30 | 1.59 |
| 150 | 38.42 | 143.53 | 0.27 | 0.97 | 0.22 | 1.48 |
| 180 | 53.22 | 159.16 | 0.29 | 0.88 | 0.49 | 0.52 |
| 210 | 64.53 | 175.24 | 0.31 | 0.83 | 0.38 | 0.54 |
| 240 | 74.27 | 204.29 | 0.31 | 0.85 | 0.32 | 0.97 |
| 270 | 80.79 | 225.75 | 0.29 | 0.34 | 0.22 | 0.76 |
| 300 | 83.36 | 230.54 | 0.28 | 0.77 | 0.09 | 0.16 |
| 330 | 84.35 | 235.86 | 0.26 | 0.71 | 0.03 | 0.18 |
| 360 | 87.56 | 240.63 | 0.24 | 0.67 | 0.12 | 0.16 |

**Table 7.4 :** Mean Net Primary Productivity (g/m²/day) of *Crinum defixum*

| Age (Days) | Aboveground | | Underground (Bulb + Root) |
|---|---|---|---|
| | Standing live | Standing dead | |
| 30 | - | - | - |
| 60 | 0.25 | | 0.60 |
| 90 | 0.32 | | 0.63 |
| 120 | 0.31 | - | 1.59 |
| 150 | 0.22 | - | 1.48 |
| 180 | 0.49 | - | 0.52 |
| 210 | 0.24 | - | 0.54 |
| 240 | 0.17 | 0.12 | 0.97 |
| 270 | -0.11 | 0.25 | 0.76 |
| 300 | -0.22 | 0.30 | 0.16 |
| 330 | -0.22 | 0.24 | 0.18 |
| 360 | -0.21 | 0.32 | 0.16 |

Net primary productivity of aboveground standing live part of *Crinum defixum* increased from 0.25 g/m²/day to 0.49 g/m²/day between 60 and 180 days. Later on it decreased to 0.21 g/m²/day at 360 days of growth. Net primary productivity of aboveground standing dead increased between 240 and 360 days of growth. The Net primary productivity of underground part of *Crinum defixum* was obtained maximum (1.59 g/m²/day) at the age of 120 days (Table 7.4).

**Production Inter-Relation :**

Aboveground and underground biomass ratio of *Crinum defixum* has been shown in Table 7.5. Aboveground/underground biomass ratio of *Crinum defixum* varied in between 0.031 and 0.444 at the different age of growth (Table 7.5).

**System Transfer Function :**

System transfer function is a good measure to express changes in an ecosystem functioning in wet and dry periods of the year (Singh and Yadava, 1974). It is an expression of the amount of input and output among the component block of any aspect of an ecosystem. Gordins. (1963) has reported it as the quantity by which the system block multiplied the input to generate the output. It reflects the orientation of the functioning of an ecosystem in space and time (Sims and Singh, 1971).

**Table 7.5 :** Production interrelation of aboveground and underground parts of *Crinum defixum*

| Age (Days) | Aboveground/Underground Biomass Ratio |
|---|---|
| 30 | 0.406 |
| 60 | 0.031 |
| 90 | 0.444 |
| 120 | 0.323 |
| 150 | 0.267 |
| 180 | 0.334 |
| 210 | 0.368 |
| 240 | 0.363 |
| 270 | 0.357 |
| 300 | 0.361 |
| 330 | 0.357 |
| 360 | 0.363 |

The output of the plants in the field is utilized at different trophic level, therefore, the input by plants themselves to the system is very poor. Moreover, plant occupy an area of short duration and are raised in succession in field. This causes a capital loss of materials. Therefore, the actual amount of material returned and the rate of return by way of decomposition of dead and post harvest organic matter remains of a particular plant under natural condition is difficult to assess. Compartment model (Figure 7.3) has been designed to express the average standing plant biomass ($g/m^2$) in different compartments and the rate of transfer ($g/m^2/day$) from one compartment to another compartment. After the harvest of the plant, the material left on the ground (dead organic remains) and underground (root and Bulb ) which ultimately become available to decomposers, is the input to the system.

The average total net primary production was found to be 204.29 $g/m^2$. Out of total net production 53.34 $g/m^2$ (26.11%) and 150.95 $g/m^2$ (73.89%) were transferred to aboveground and underground compartments, respectively. The rate of total net production was found to be 0.567 $g/m^2/day$. The rate of the transfer of net production to the aboveground and underground compartments were 0.148 $g/m^2/day$ and 0.419 $g/m^2/day$ respectively. The average standing dead production was found to be 22.99 $g/m^2$. The rate of transfer from aboveground compartment to

TNP = Total net production
AG = Aboveground
UG = Underground
SD = Standing dead

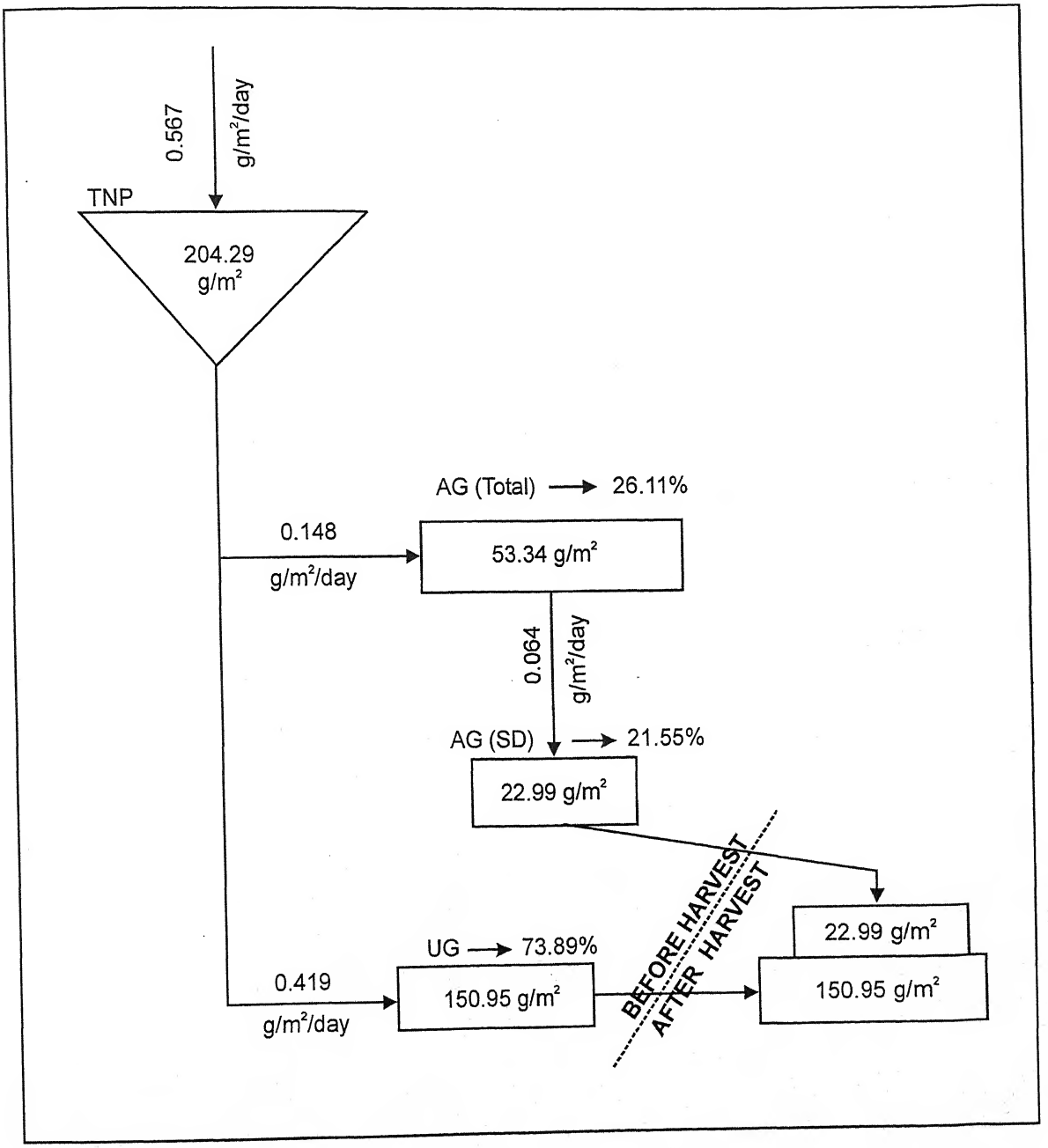


Fig. 7.3 : Compartment model showing average standing crop biomass, flow rate and estimated release

standing dead compartment was found to be 0.064 g/m$^2$/day. It was 21.55% of the aboveground net production. The estimated biomass after the harvest of plant which causes input to the system after decomposition by decomposer was 173.94 g/m$^2$.

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# CHAPTER - VIII

# NUTRIENT DYNAMICS

# NUTRIENT DYNAMICS

The plants need nutrients as a raw materials for the different metabolic activity which they derive from the soil. Plant nutrition is ultimately concerned with the traffic of elements and compound between the totality of living things and the non-living surroundings (Epistein, 1972). Growth and production of an ecosystem depends largely on the cycling of nutrients. The efficiency with which the nutrients are utilized in any ecosystem depends on the amount and frequency of recycling of the nutrients. In the cropland ecosystem the uptake, retention and release of nutrients are not completed since the yield is transferred to different trophic levels.

The plants absorb a very small fraction of dissolved minerals through their roots. For efficient growth of the terrestrial plants, the soil should be adequately fertile. The fertility of the soil rests upon the factors such as physical and chemical nature of the soil. Nutrient status of a particular type of soil, its uptake by plants and accumulation in different plant parts are important aspects of production ecology (Ovington and Medgwick, 1959). Some valuable

contribution to the role of nutrients and nutrient dynamics in crop plant soil system have been made by William (1955), Gilbert (1957), Aslander (1958), Russel (1963), Dyakav (1969), Hanway and Weber (1971), Skelton and Shear (1971), Marwah (1972), Bayers and Walmsley (1974), Kollman *et al.* (1974), Dhliwayo and Whingwiri (1984), Rao *et al.* (1986), Reddy *et al.* (1986), Nath (1990), Vihari (1992), Pandey and Kumari (1992), Pandey and Nath (1990).

This chapter deals with the nutrient dynamics i.e. concentration, uptake, retention and release of nitrogen, phosphorus, potassium, sodium, calcium and magnesium of *Crinum defixum* at various stages of plant growth.

## RESULTS

### Nitrogen

Concentration of nitrogen in aboveground parts i.e. standing live was found to be increasing from 1.28 to 1.55% and it ranged from 0.89% to 0.69% in standing dead part of the plant between 210 to 360 days of growth i.e. it was found in decreasing order. The percentage nitrogen concentration in the underground parts i.e. Bulb and root parts of the plant ranged between 1.08 to 0.93% and it was found maximum in 30 days of plant growth (Table 8.1 and Figure 8.1).

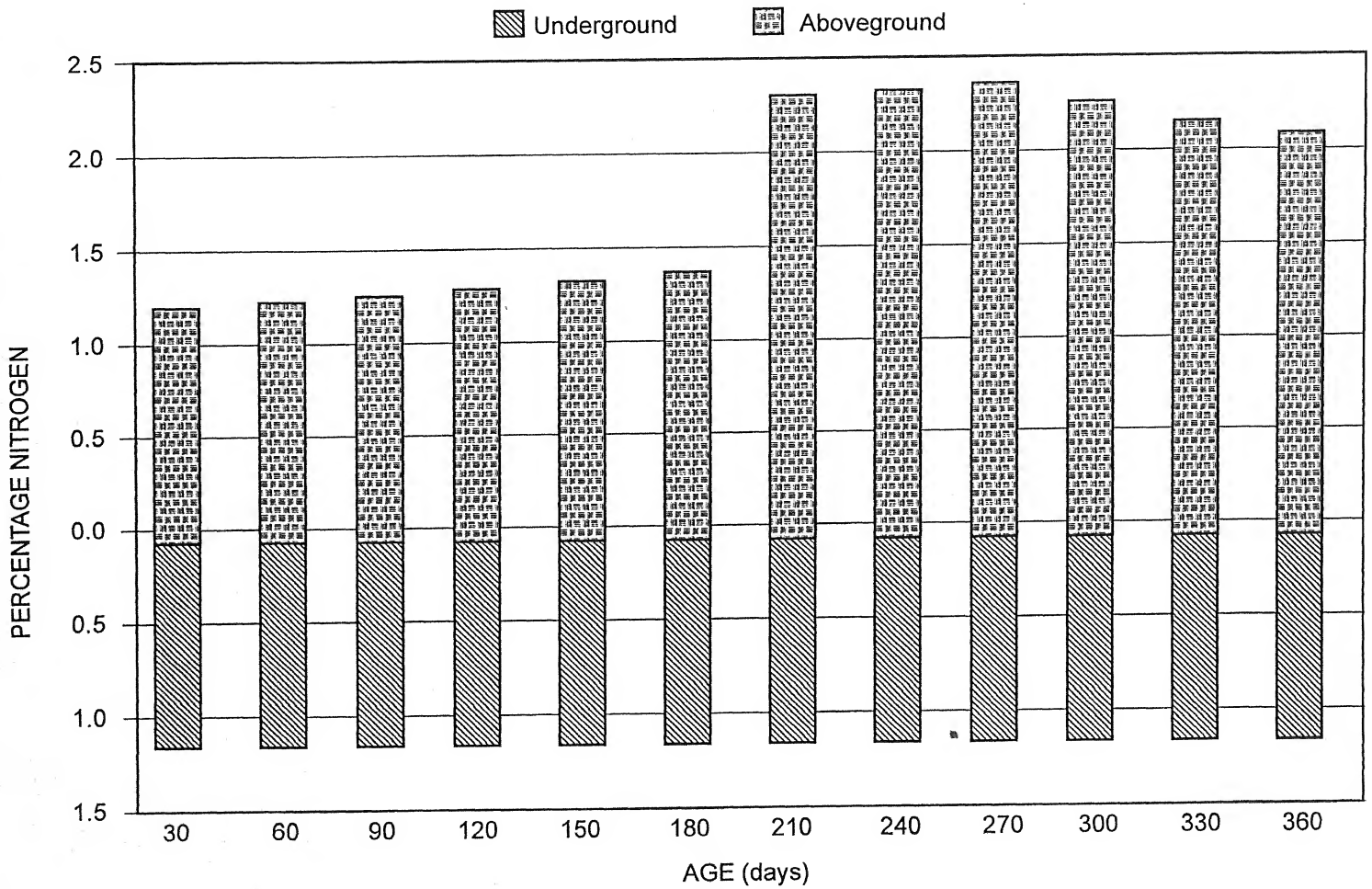


Fig. 8.1 : Percentage total nitrogen in aboveground and underground part of *Crinum defixum*

**Table 8.1 :** Percentage of total nitrogen in the component parts of *Crinum defixum*

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 1.28±0.038 | - | 1.08 ± 0.032 |
| 60 | 1.30 ± 0.039 | - | 1.07 ± 0.053 |
| 90 | 1.32±0.035 | - | 1.06 ± 0.031 |
| 120 | 1.35 ± 0.040 | - | 1.06 ± 0.031 |
| 150 | 1.38 ± 0.027 | - | 1.05 ± 0.030 |
| 180 | 1.42 ± 0.028 | - | 1.03 ± 0.051 |
| 210 | 1.47 ± 0.044 | 0.89 ± 0.026 | 1.01 ± 0.050 |
| 240 | 1.51 ± 0.030 | 0.87 ± 0.017 | 0.99 ± 0.029 |
| 270 | 1.55 ± 0.077 | 0.86 ± 0.043 | 0.98 ± 0.049 |
| 300 | 1.52 ± 0.045 | 0.79 ± 0.023 | 0.97 ± 0.019 |
| 330 | 1.49 ± 0.074 | 0.72 ± 0.014 | 0.95 ± 0.028 |
| 360 | 1.45 ± 0.043 | 0.69 ± 0.013 | 0.93 ± 0.018 |

± = Standard Deviation

Accumulation of nitrogen in the aboveground part i.e. standing live of the plant *Crinum defixum* was found to be increasing till 240 days of the plant growth which is 0.991 g/m$^2$ and later on it decreased to 0.620 g/m$^2$ in 360 days of plant growth (Table 8.2). The accumulation of nitrogen in standing dead part was found to be increasing from 0.035 to 0.309 g/m$^2$ in 210 to 360 days of the plant growth. Accumulation of nitrogen in underground parts i.e. bulb and roots was found to be increasing from 30 days to the final harvest i.e. 360 days of the plant growth and ranged from 0.151 to 2.406 g/m$^2$ (Table 8.2). Accumulation of total nitrogen in plant gradually increases up to 270 days of the plant growth and after this it decreased (Figure 8.2).

It was found that the uptake of nitrogen increased from 30 to 210 days and later on decreased at 360 days of the plant growth (Table 8.3). The minimum uptake of nitrogen was 0.007 g/m$^2$/day and maximum 0.017 g/m$^2$/day at 210 day of plant growth. Release of nitrogen was reported at the age from 210 to 360 days of the plant growth and ranged from 0.0001 to 0.0009 g/m$^2$/day (Table 8.3).

**Phosphorus**

The concentration of phosphorus in aboveground parts i.e. standing live was found to be increasing from 0.165% to 0.182 %

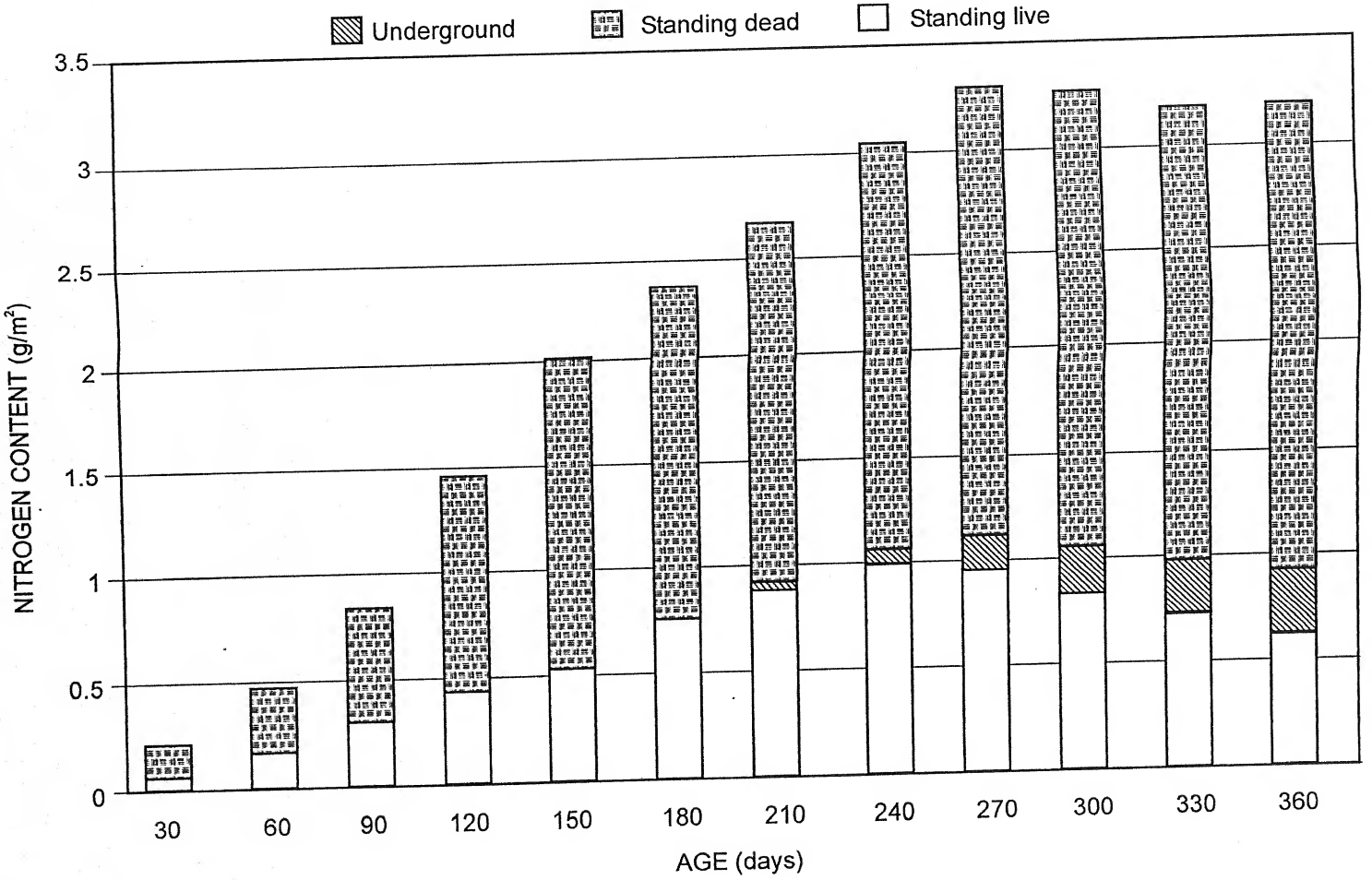


Fig. 8.2 : Total nitrogen content ($g/m^2$) in component part of *Crinum defixum*

**Table 8.2 :** Accumulation of nitrogen ($g/m^2$) in component parts of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.073 | - | 0.151 |
| 60 | 0.172 | - | 0.344 |
| 90 | 0.300 | - | 0.542 |
| 120 | 0.430 | - | 1.049 |
| 150 | 0.530 | - | 1.507 |
| 180 | 0.755 | - | 1.639 |
| 210 | 0.889 | 0.035 | 1.769 |
| 240 | 0.991 | 0.066 | 2.022 |
| 270 | 0,964 | 0.160 | 2.212 |
| 300 | 0.845 | 0.218 | 2.236 |
| 330 | 0.732 | 0.253 | 2.240 |
| 360 | 0.620 | 0.309 | 2.306 |

± = Standard Deviation

**Table 8.3 :** Uptake, release and retention ($g/m^2/day$) of nitrogen by *Crinum defixum*

| Age (Days) | Uptake | Retention | Release |
|---|---|---|---|
| 30 | 0.007 | 0.007 | - |
| 60 | 0.008 | 0.008 | - |
| 90 | 0.009 | 0.009 | - |
| 120 | 0.012 | 0.012 | - |
| 150 | 0.013 | 0.013 | - |
| 180 | 0.013 | 0.013 | - |
| 210 | 0.017 | 0.016 | 0.0001 |
| 240 | 0.013 | 0.012 | 0.0003 |
| 270 | 0.012 | 0.011 | 0.0006 |
| 300 | 0.011 | 0.010 | 0.0007 |
| 330 | 0.0097 | 0.008 | 0.0008 |
| 360 | 0.0092 | 0.008 | 0.0009 |

between 30 to 180 days of plant growth (Table 8.4). Later on it decreased to 0.0125% at final harvest i.e. 360 days. The maximum concentration of phosphorus in standing dead was recorded to be 0.153% at 270 days of plant growth. The maximum concentration of phosphorus in the underground parts was found to 0.174% at initial stage of growth. Later on it decreased to 0.123% at the age of 360 days of the plant growth (Table 8.4 and Figure 8.3).

Accumulation of phosphorus in the aboveground (standing live) was found to be increased from 0.007 $g/m^2$ to 0.098 $g/m^2$ at the age from 30 to 240 days of plant growth, later on decreased to 0.051 $g/m^2$ at 360 days of growth (Table 8.5). In underground parts it was recorded to increase from 0.034 to 0.448 $g/m^2$ at the age of 30 to 330 days of plant growth (Table 8.5). Total phosphorus content was noted to increase up to 330 days of plant growth then it went on decreasing up to last harvesting of plant (Figure 8.4).

Total uptake of phosphorus was recorded maximum at 150 days of growth which was 0.0023 $g/m^2$/day. Maximum Retention was recorded 0.0023 $g/m^2$/day at 150 days of growth and later on decreased to 0.0012 $g/m^2$/day at 360 days of plant growth (Table 8.6).

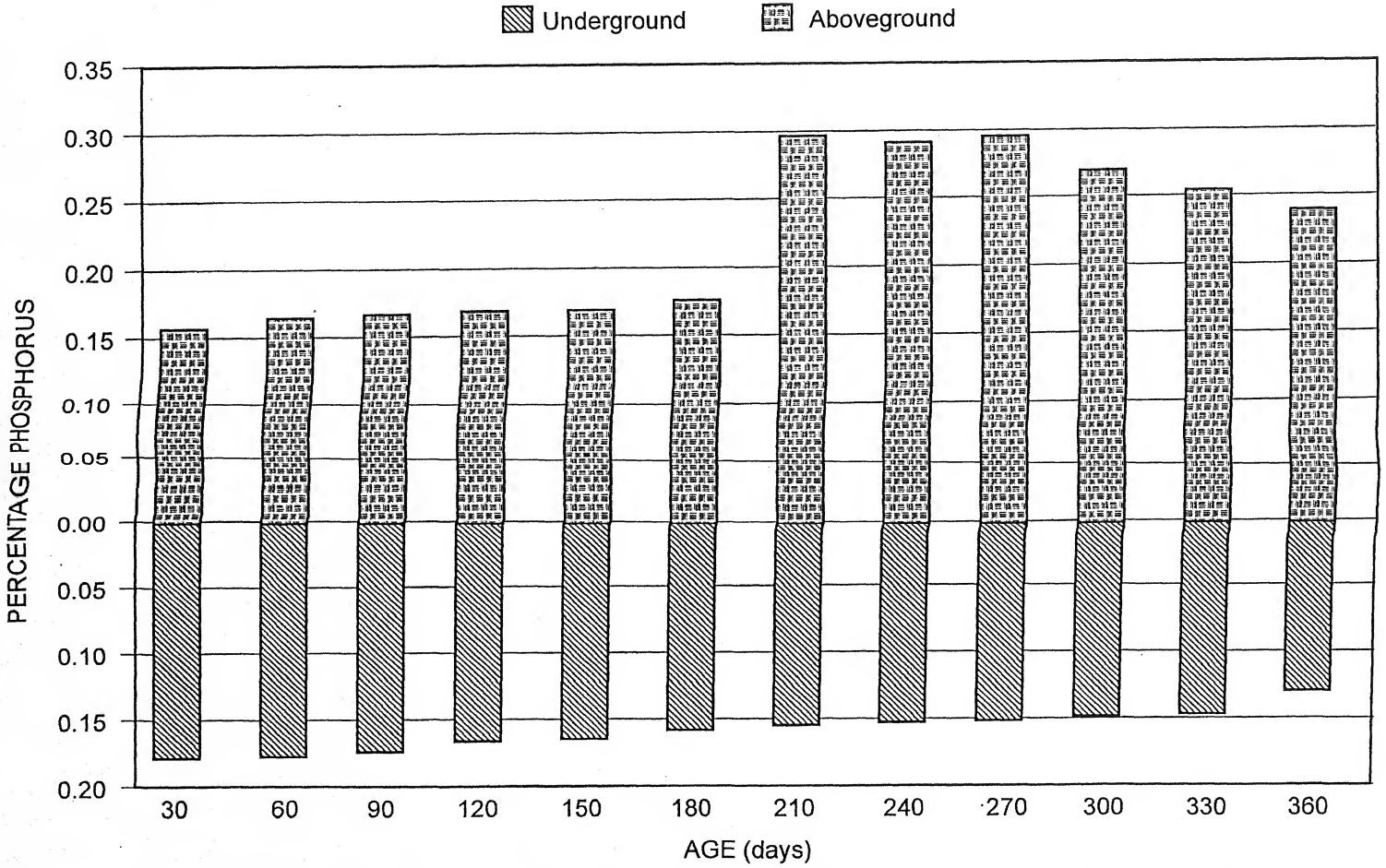


Fig. 8.3 : Percentage total phosphorus in aboveground and underground part of *Crinum defixum*

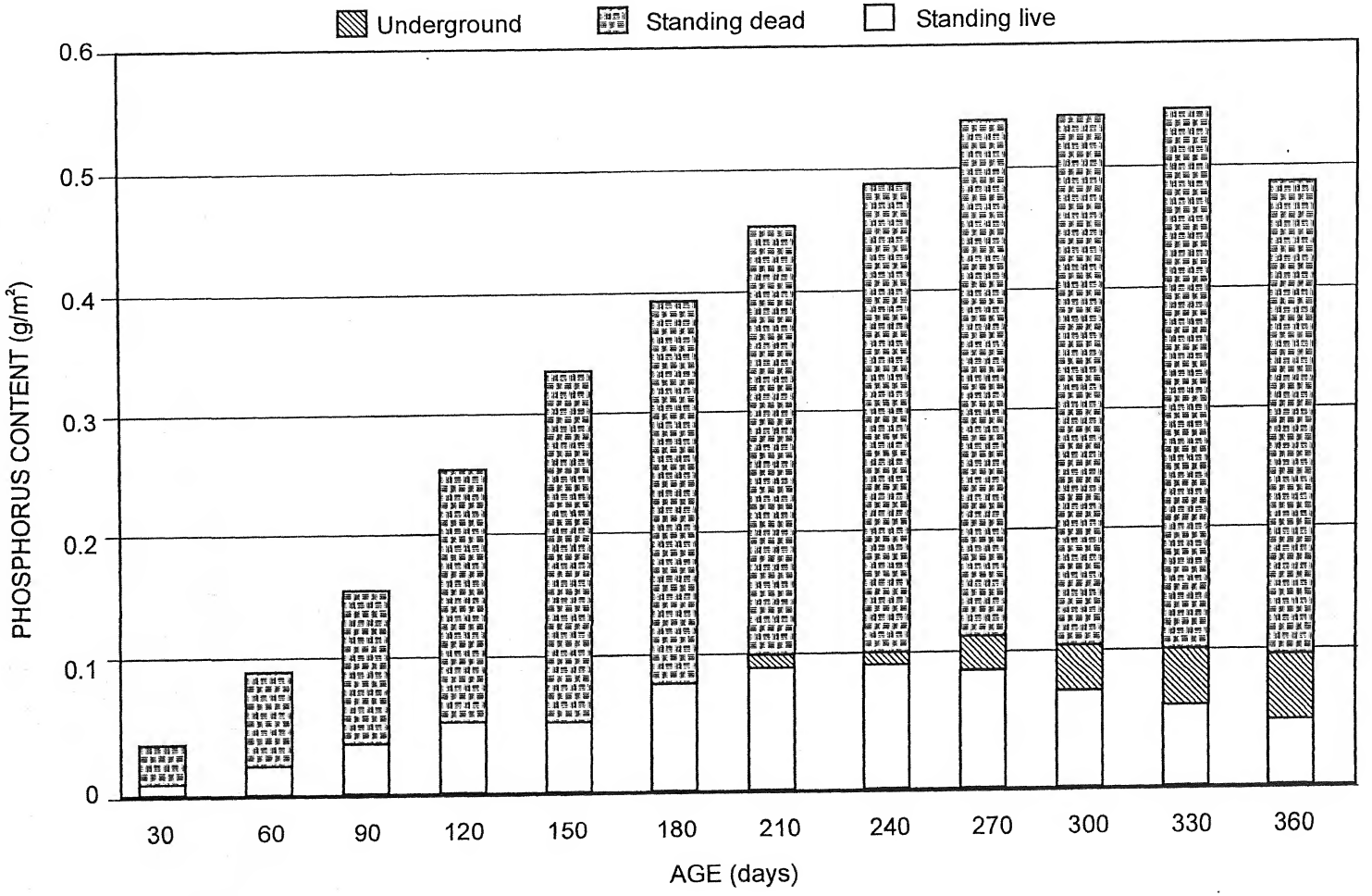


Fig. 8.4 : Total phosphorus content ($g/m^2$) in component part of *Crinum defixum*

**Table 8.4 :** Percentage of total phosphorus in the different components of *Crinum defixum*

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | (Bulb & Root) |
| 30 | 0.165 ± 0.0156 | - | 0.174 ± 0.0165 |
| 60 | 0.172 ± 0.0163 | - | 0.172 ± 0.0137 |
| 90 | 0.174 ± 0.0087 | - | 0.170 ± 0.0162 |
| 120 | 0.175 ± 0.0166 | - | 0.163 ± 0.0133 |
| 150 | 0.176 ± 0.0088 | - | 0.161 ± 0.0128 |
| 180 | 0.182 ± 0.0173 | - | 0.154 ± 0.0123 |
| 210 | 0.163 ± 0.0130 | 0.142 ± 0.0113 | 0.150 ± 0.0120 |
| 240 | 0.154 ± 0.0146 | 0.145 ± 0.0138 | 0.147 ± 0.0139 |
| 270 | 0.152 ± 0.0144 | 0.153 ± 0.0145 | 0.145 ± 0.0116 |
| 300 | 0.144 ± 0.0115 | 0.135 ± 0.0108 | 0.143 ± 0.0114 |
| 330 | 0.132 ± 0.0125 | 0.132 ± 0.0105 | 0.142 ± 0.0134 |
| 360 | 0.125 ± 0.0118 | 0.124 ± 0.0118 | 0.123 ± 0.0098 |

± = Standard Deviation

**Table 8.5 :** Accumulation of phosphorus ($g/m^2$) in the component parts of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.007 | - | 0.034 |
| 60 | 0.022 | - | 0.077 |
| 90 | 0.038 | - | 0.126 |
| 120 | 0.054 | - | 0.209 |
| 150 | 0.055 | - | 0.291 |
| 180 | 0.085 | - | 0.318 |
| 210 | 0.097 | 0.007 | 0.359 |
| 240 | 0.098 | 0.010 | 0.389 |
| 270 | 0.093 | 0.027 | 0.429 |
| 300 | 0.077 | 0.036 | 0.439 |
| 330 | 0.064 | 0.045 | 0.448 |
| 360 | 0.051 | 0.053 | 0.393 |

**Table 8.6 :** Uptake, release and retention ($g/m^2$) of phosphorus by *Crinum defixum*

| Age (Days) | Uptake | Release | Retention |
|---|---|---|---|
| 30 | 0.0013 | - | 0.0013 |
| 60 | 0.0016 | - | 0.0016 |
| 90 | 0.0018 | - | 0.0018 |
| 120 | 0.0022 | - | 0.0022 |
| 150 | 0.0023 | - | 0.0023 |
| 180 | 0.0022 | - | 0.0022 |
| 210 | 0.0022 | 0.00003 | 0.00217 |
| 240 | 0.0021 | 0.00004 | 0.00206 |
| 270 | 0.0020 | 0.00010 | 0.0019 |
| 300 | 0.0018 | 0.00012 | 0.0017 |
| 330 | 0.0016 | 0.00013 | 0.0015 |
| 360 | 0.0013 | 0.00014 | 0.0012 |

## Potassium

The concentration of potassium in the standing live parts was found to be increasing from 1.43 to 1.51% between 30 and 270 days of plant growth (Table 8.7). The maximum concentration of potassium in standing dead was recorded 1.27% at 210 days. Concentration of potassium in underground parts was found to be increasing from 1.29 to 1.42% between 30 to 270 days. Later on it decreased to 1.34% at the final harvest (Table 8.7 and Figure 8.5).

Accumulation of potassium in standing live part of plant increased from 0.081 to 0.984 $g/m^2$ between 30 and 240 days of growth, later on it decreased to 0.620 $g/m^2$ at 360 days of harvest. In standing dead part of the plant maximum accumulation of potassium was reported to be 0.546 $g/m^2$ at 360 days of plant. The maximum accumulation of potassium in underground part was found 3.205 $g/m^2$ at 270 days of plant growth. Later on it decreased 3.124 $g/m^2$ at 360 days of plant (Table 8.8). Accumulation of potasium in the plant increased up to 330 days of plant growth then it decreased up to harvesting (Figure 8.6).

The maximum uptake of potassium was recorded 0.0164 $g/m^2/day$ at 240 days of growth period. Later on it decreased to 0.0122 $g/m^2/day$ at 360 days of final harvest. The release of potassium was reported at the age from 210 to 360 days of growth.

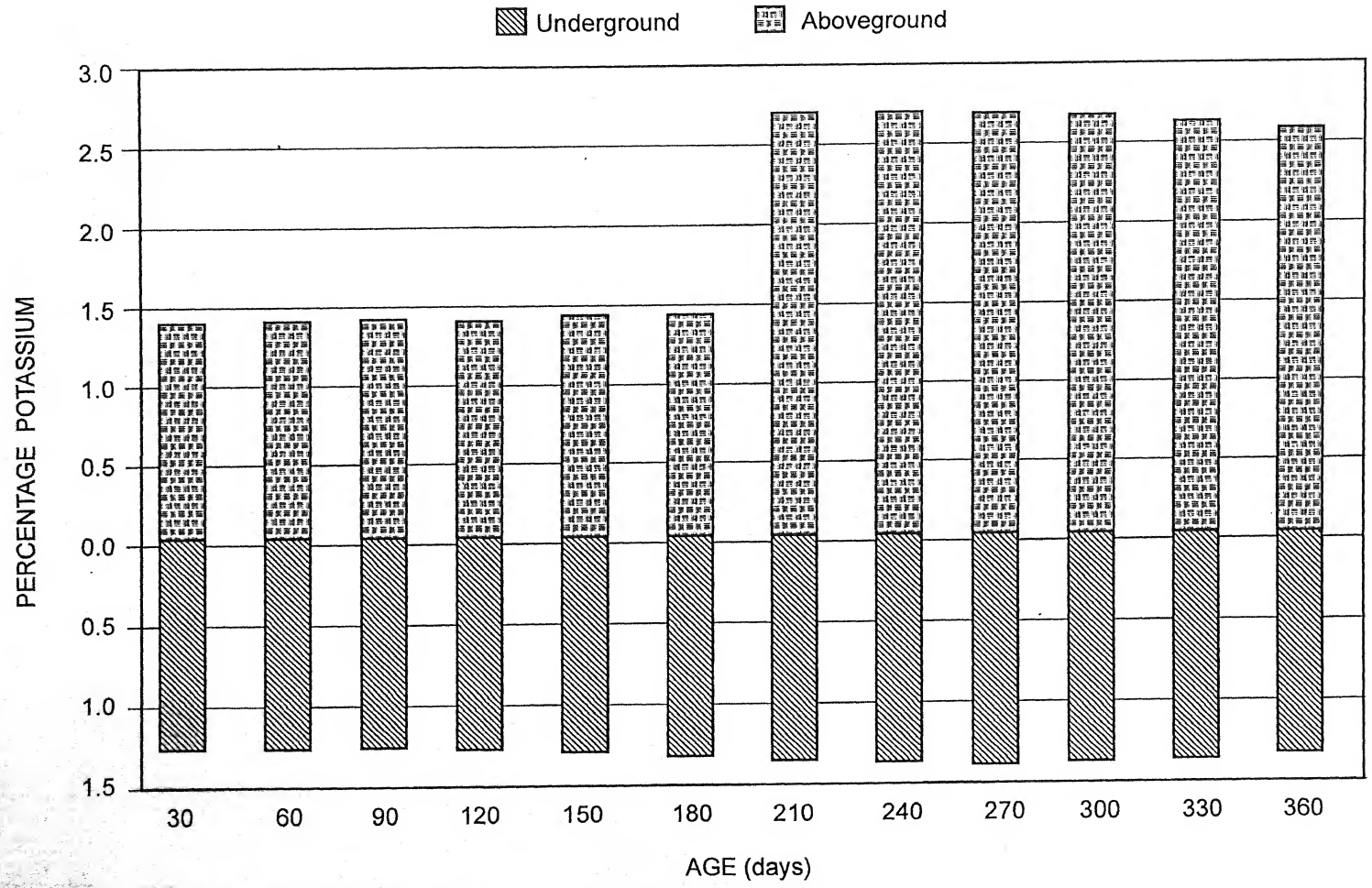


Fig. 8.5 : Percentage total potassium in aboveground and underground part of *Crinum defixum*

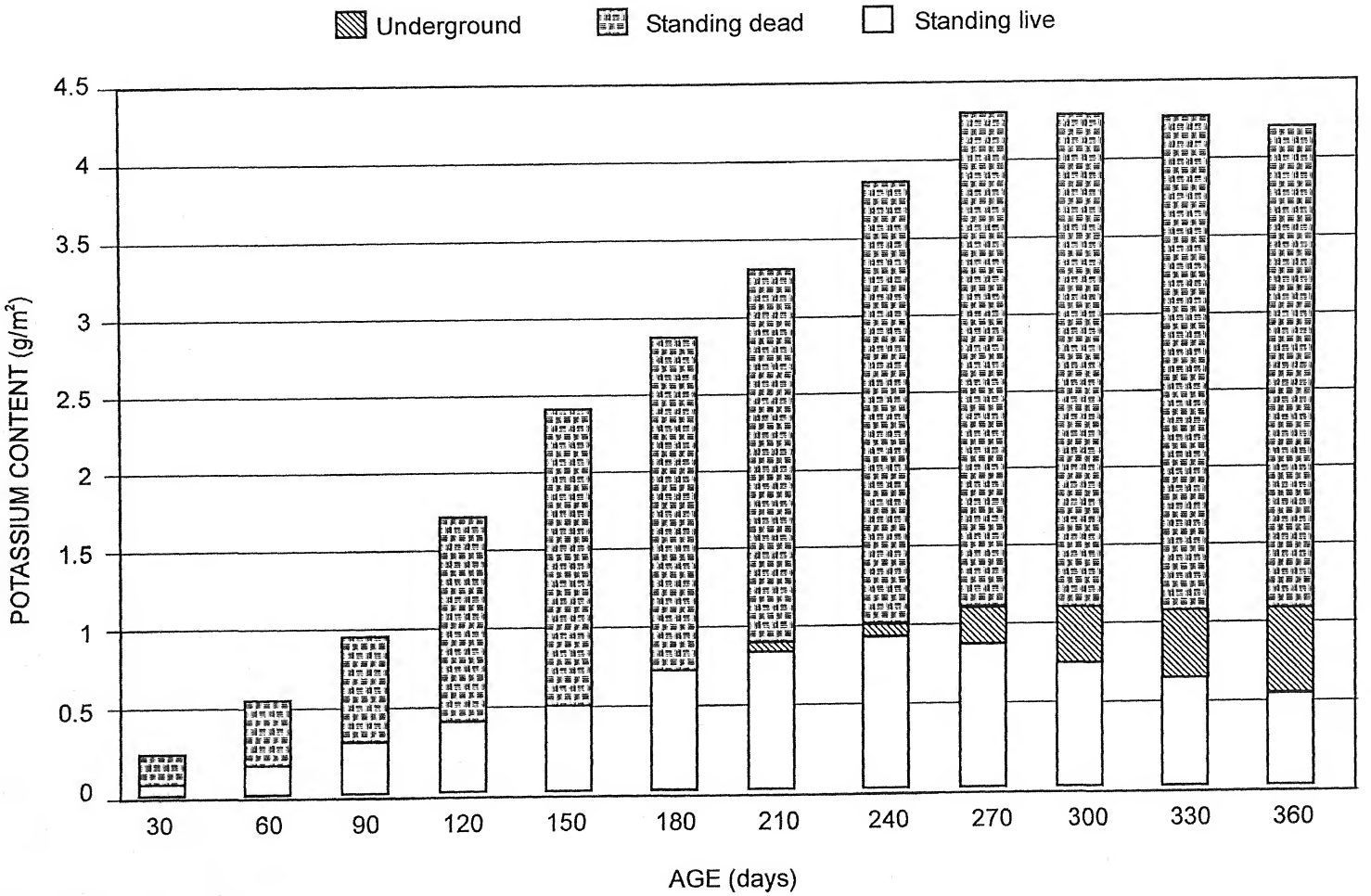


Fig. 8.6 : Total potassium content ($g/m^2$) in component part of *Crinum defixum*

**Table 8.7 :** Percentage total potassium in the different parts of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | (Bulb & Root) |
| 30 | 1.43 ± 0.128 | - | 1.29 ± 0.116 |
| 60 | 1.44 ± 0.028 | - | 1.30 ± 0.026 |
| 90 | 1.45 ± 0.014 | - | 1.31 ± 0.118 |
| 120 | 1.45 ± 0.131 | - | 1.32 ± 0.026 |
| 150 | 1.47 ± 0.029 | - | 1.33 ± 0.013 |
| 180 | 1.48 ± 0.074 | - | 1.35 ± 0.122 |
| 210 | 1.49 ± 0.139 | 1.27 ± 0.114 | 1.38 ± 0.028 |
| 240 | 1.50 ± 0.030 | 1.26 ± 0.025 | 1.40 ± 0.126 |
| 270 | 1.51 ± 0.015 | 1.25 ± 0.013 | 1.42 ± 0.029 |
| 300 | 1.49 ± 0.134 | 1.24 ± 0.112 | 1.39 ± 0.014 |
| 330 | 1.48 ± 0.029 | 1.23 ± 0.024 | 1.37 ± 0.123 |
| 360 | 1.45 ± 0.015 | 1.22 ± 0.109 | 1.34 ± 0.027 |

± = Standard Deviation

**Table 8.8 :** Accumulation of potassium ($g/m^2$) in the different parts of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.081 | - | 0.181 |
| 60 | 0.190 | - | 0.418 |
| 90 | 0.329 | - | 0.670 |
| 120 | 0.462 | - | 1.306 |
| 150 | 0.564 | - | 1.909 |
| 180 | 0.787 | - | 2.148 |
| 210 | 0.901 | 0.051 | 2.418 |
| 240 | 0.984 | 0.092 | 2.860 |
| 270 | 0.939 | 0.233 | 3.205 |
| 300 | 0.829 | 0.343 | 3.204 |
| 330 | 0.727 | 0.432 | 3.203 |
| 360 | 0.620 | 0.546 | 3.124 |

The maximum retention of potassium was reported 0.1636 g/m$^2$/day at 240 days of plant (Table 8.9).

**Sodium**

The maximum concentration of sodium in standing live parts was found to be 0.38 to 0.69% at the age of 30 to 270 days of plant (Table 8.10). Later on it decreased to 0.51% at 360 days of growth. Sodium in standing dead part of plant was recorded maximum of 0.70% at the age of 300 days of plant. The concentration of sodium in underground part i.e. bulb and root was found to increase from 0.49 to 0.98% between 30 to 270 days of plant growth. Later on it decreased 0.89% at final harvest i.e. 360 days (Table 8.10 and Figure 8.7).

Accumulation of sodium in aboveground i.e. standing live part was found to be increasing from 0.021 to 0.439 g/m$^2$ between 30 to 240 days of plant (Table 8.11). Accumulation of sodium in standing dead part of sudarshan was found to be maximum at the age of 360 days. The accumulation of sodium in underground part was found to be increasing from 0.068 to 2.212 g/m$^2$ at the age of 30 to 270 days of growth. Later on it decreased to 2.141 g/m$^2$ at 360 days of plant growth (Table 8.11 and Figure 8.8).

The uptake of sodium was found to be maximum 0.0122 g/ m$^2$/day at 240 days of growth. Later on it decreased to 0.072 g/m$^2$/

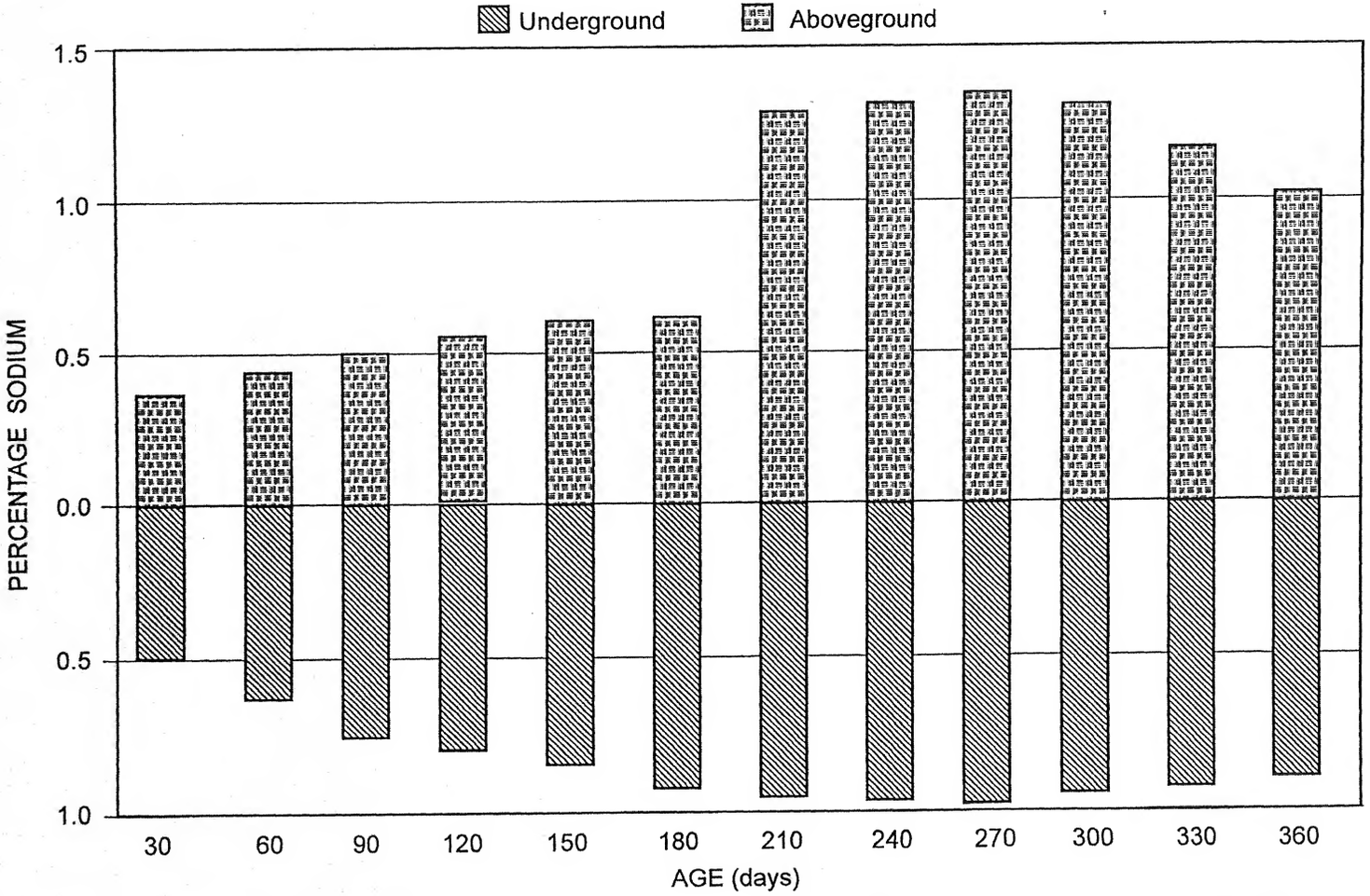


Fig. 8.7 : Percentage total sodium in aboveground and underground part of *Crinum defixum*

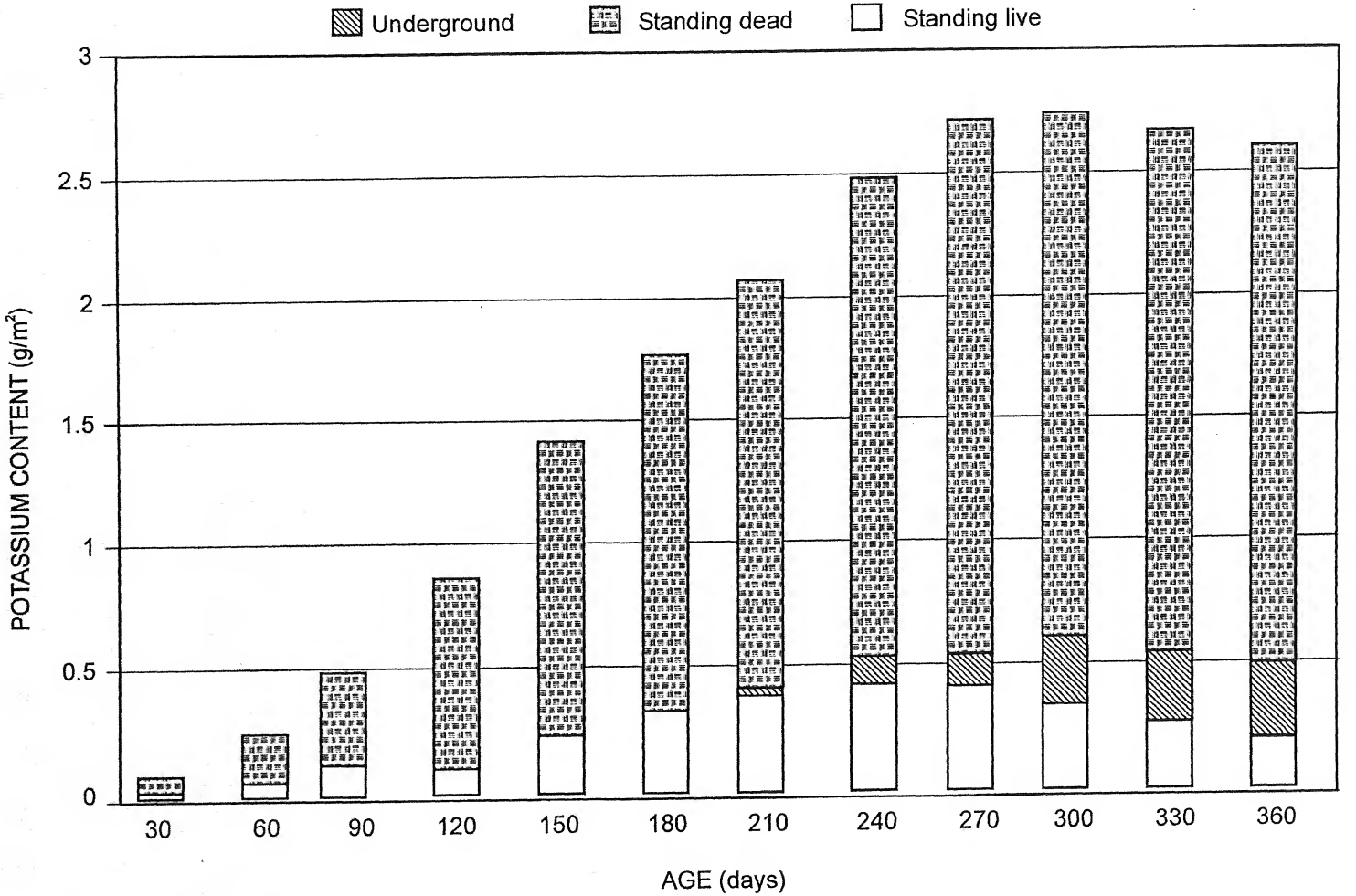


Fig. 8.8 : Total sodium content ($g/m^2$) in component part of *Crinum defixum*

**Table 8.9 :** Uptake, release and retention ($g/m^2/day$) of potassium by *Crinum defixum*

| Age (Days) | Uptake | Release | Retention |
|---|---|---|---|
| 30 | 0.0087 | - | 0.0087 |
| 60 | 0.0101 | - | 0.0101 |
| 90 | 0.0111 | - | 0.0111 |
| 120 | 0.0147 | - | 0.0147 |
| 150 | 0.0164 | - | 0.0164 |
| 180 | 0.0163 | - | 0.0163 |
| 210 | 0.0160 | 0.0002 | 0.0158 |
| 240 | 0.0164 | 0.0004 | 0.1636 |
| 270 | 0.0162 | 0.0008 | 0.0154 |
| 300 | 0.0145 | 0.0011 | 0.0134 |
| 330 | O.0133 | 0.0013 | 0.0120 |
| 360 | 0.0122 | 0.0015 | 0.0107 |

**Table 8.10 :** Percentage of total sodium in the different components of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | (Bulb + Root) |
| 30 | 0.38 ± 0.008 | - | 0.49 ± 0.009 |
| 60 | 0.46 ± 0.041 | - | 0.62 ± 0.063 |
| 90 | 0.54 ± 0.010 | - | 0.75 ± 0.067 |
| 120 | 0.58 ± 0.052 | - | 0.79 ± 0.015 |
| 150 | 0.63 ± 0.056 | - | 0.84 ± 0.092 |
| 180 | 0.64 ± 0.012 | - | 0.92 ± 0.018 |
| 210 | 0.66 ± 0.059 | 0.65 ± 0.058 | 0.95 ± 0.085 |
| 240 | 0.67 ± 0.014 | 0.67 ± 0.073 | 0.97 ± 0.106 |
| 270 | 0.69 ± 0.076 | 0.68 ± 0.014 | 0.98 ± 0.019 |
| 300 | 0.63 ± 0.015 | 0,70 ± 0.077 | 0.94 ± 0.095 |
| 330 | 0.58 ± 0.012 | 0.61 ± 0.012 | 0.92 ± 0.101 |
| 360 | 0.51 ± 0.056 | 0.53 ± 0.048 | 0.89 ± 0.017 |

± = Standard Deviation

**Table 8.11 :** Accumulation of sodium ($g/m^2$) in the different components of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.021 | | 0.068 |
| 60 | 0.060 | - | 0.199 |
| 90 | 0.122 | - | 0.383 |
| 120 | 0.107 | - | 0.782 |
| 150 | 0.245 | - | 1.205 |
| 180 | 0.340 | - | 1.464 |
| 210 | 0.399 | 0.026 | 1.664 |
| 240 | 0.439 | 0.111 | 1,981 |
| 270 | 0.429 | 0.126 | 2.212 |
| 300 | 0.350 | 0.277 | 2.167 |
| 330 | 0.285 | 0.280 | 2.165 |
| 360 | 0.218 | 0.301 | 2.141 |

day at 360 days of harvest. The release of sodium was reported at the age from 210 to 360 days. The maximum retention of sodium was recorded 0.0101 g/m$^2$/day at 240 days of plant growth (Table 8.12).

### Calcium

The concentration of calcium in the standing live part of plant was found to be increasing from 1.14 to 1.23% between 30 to 270 days (Table 8.13). The concentration of calcium in standing dead part was found to be increased from 1.14 to 1.19% at 210 to 300 days of plant. Calcium concentration in underground parts i.e. bulb and root was found to increase from 1.10 to 1.216% at 30 to 270 days of plant growth. Later on it decreased to 1.18% at 360 days of plant harvest (Table 8.13 and Figure 8.9).

Accumulation of calcium in standing live part was found to be increasing from 0.065 to 0.807 g/m$^2$ between 30 to 240 days of growth (Table 8.14). Later on it decreased to 0.504 g/m$^2$ at 360 days of growth. The maximum accumulation of calcium in standing dead part of sudarshan was recorded 0.519 g/m$^2$ at the final harvest i.e. 360 days. Accumulation of calcium in root has increased from 0.154 to 2.839 g/m$^2$ at 30 to 360 days of plant growth (Table 8.14). Total calcium content was gradually increased up to the harvesting of the plant i.e. 360 days of plant growth (Figure 8.10).

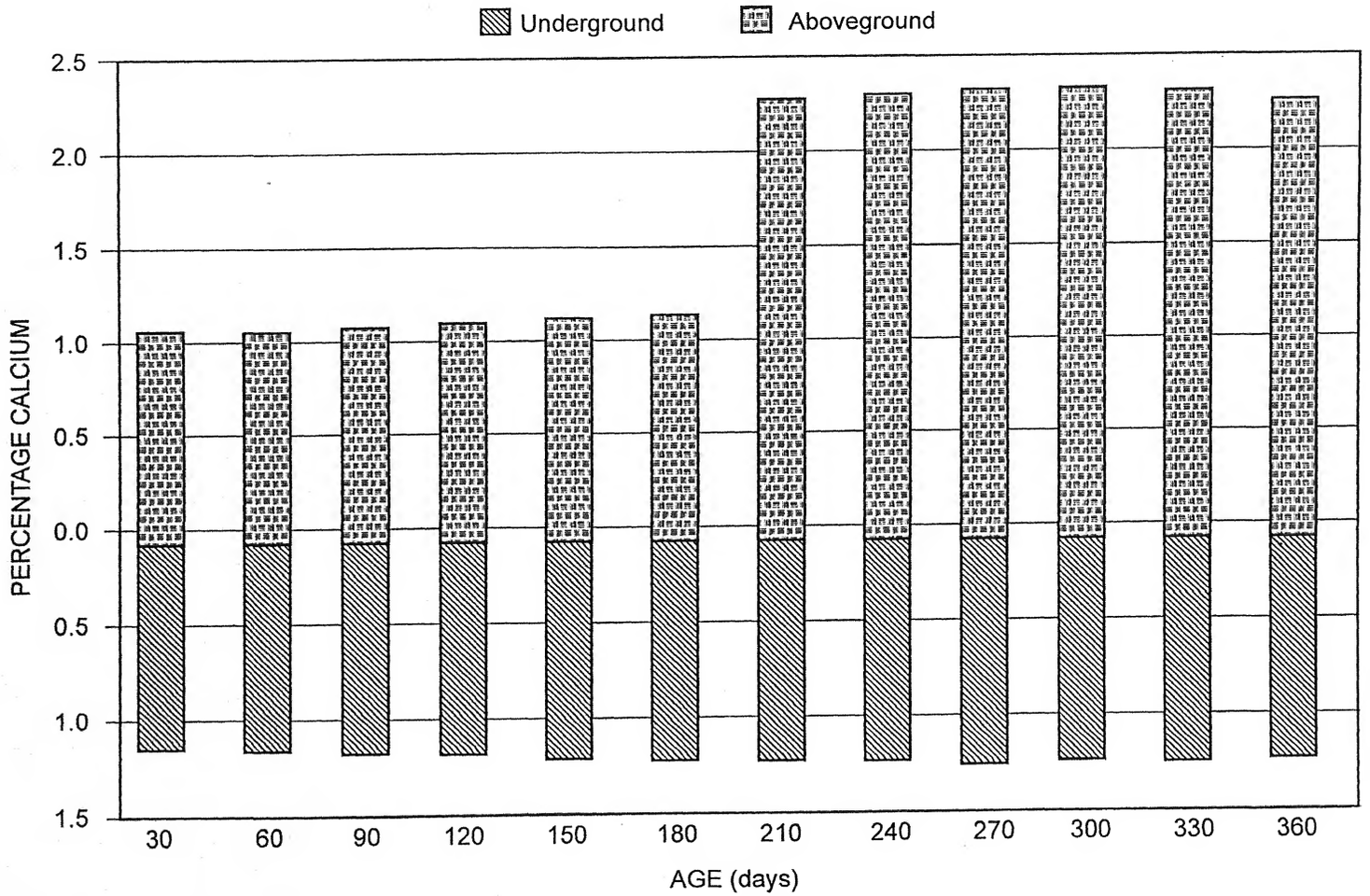


Fig. 8.9 : Percentage total calcium in aboveground and underground part of *Crinum defixum*

**Table 8.12 :** Uptake, release and retention ($g/m^2/day$) of sodium by *Crinum defixum*

| Age (Days) | Uptake | Release | Retention |
|---|---|---|---|
| 30 | 0.0029 | - | 0.0029 |
| 60 | 0.0043 | - | 0.0043 |
| 90 | 0.0056 | - | 0.0056 |
| 120 | 0.0074 | - | 0.0074 |
| 150 | 0.0097 | - | 0.0097 |
| 180 | 0.0100 | - | 0.0100 |
| 210 | 0.0099 | 0.00012 | 0.0097 |
| 240 | 0.0122 | 0.00210 | 0.0101 |
| 270 | 0.0102 | 0.00046 | 0.0097 |
| 300 | 0.0093 | 0.00092 | 0.0083 |
| 330 | 0.0078 | 0.00095 | 0.0068 |
| 360 | 0.0072 | 0.00065 | 0.0065 |

**Table 8.13 :** Percentage of total calcium in the different components of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | (Bulb + Root) |
| 30 | 1.14 ± 0.102 | - | 1.10 ±0.022 |
| 60 | 1.14 ± 0.057 | - | 1.11 ± 0.099 |
| 90 | 1.15 ± 0.058 | - | 1.13 ± 0.101 |
| 120 | 1.17 ± 0.105 | - | 1.14 ± 0.023 |
| 150 | 1.20 ± 0.060 | - | 1.17 ± 0.058 |
| 180 | 1.21 ± 0.024 | | 1.18 ± 0.106 |
| 210 | 1.22 ± 0.035 | 1.14 ± 0.034 | 1.19 ± 0.024 |
| 240. | 1.23 ± 0.110 | 1.16 ± 0.104 | 1.19 ± 0.059 |
| 270 | 1.23 ± 0.051 | 1.17 ± 0.023 | 1.21 ± 0.024 |
| 300 | 1.22 ± 0.061 | 1.19 ± 0.107 | 1.20 ± 0.108 |
| 330 | 1.21 ± 0.108 | 1.18 ± 0.035 | 1.20 ± 0.036 |
| 360 | 1.18 ± 0.059 | 1.16 ± 0.104 | 1.18 ± 0.023 |

± = Standard Deviation

**Table 8.14 :** Accumulation of cacium ($g/m^2$) in the different components of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.065 | - | 0.154 |
| 60 | 0.151 | - | 0.357 |
| 90 | 0.261 | - | 0.577 |
| 120 | 0.373 | - | 1.128 |
| 150 | 0.461 | - | 1.679 |
| 180 | 0.643 | - | 1.878 |
| 210 | 0.738 | 0.067 | 2.085 |
| 240 | 0.807 | 0.088 | 2.431 |
| 270 | 0.765 | 0.218 | 2.731 |
| 300 | 0.678 | 0.329 | 2.766 |
| 330 | 0.599 | 0.415 | 2.830 |
| 360 | 0.504 | 0.519 | 2.839 |

The maximum uptake of calcium was reported to 0.0139. g/ $m^2$/day at 240 days of plant growth (Table 8.15). Later on it decreased to 0.0107 g/$m^2$/day at 360 days of growth. The release of calcium was reported at the age of 210 to 360 days of plant. The retention of calcium was increased from 0.0073 to 0.0135 g/$m^2$/day between 30 to 360 days of plant (Table 8.15).

**Magnesium**

The concentration of magnesium in standing live part of plant was found to be increasing from 0.47 to 0.53% between 30 to 270 days of plant (Table 8.16). Later on it decreased to 0.43% at 360 days of plant growth. The concentration of magnesium in standing dead part of the sudarshan was reported maximum at 270 days of plant. The maximum concentration of magnesium in the underground parts of plant was found to be 0.46 to 0.52% between 30 and 270 days of plant growth. Later on it decreased to 0.46% at 360 days of plant (Table 8.16 and Figure 8.11).

Accumulation of magnesium in standing live of aboveground part of plant was found to be increasing from 0.026 to 0.341 g/$m^2$ between 30 and 240 days of plant growth (Table 8.17). Later on it decreased to 0.183 g/$m^2$ at 360 days of plant. Accumulation of magnesium in underground part increased from 0.064 to 1. 173 g/$m^2$ between 30 and 270 days of plant growth.

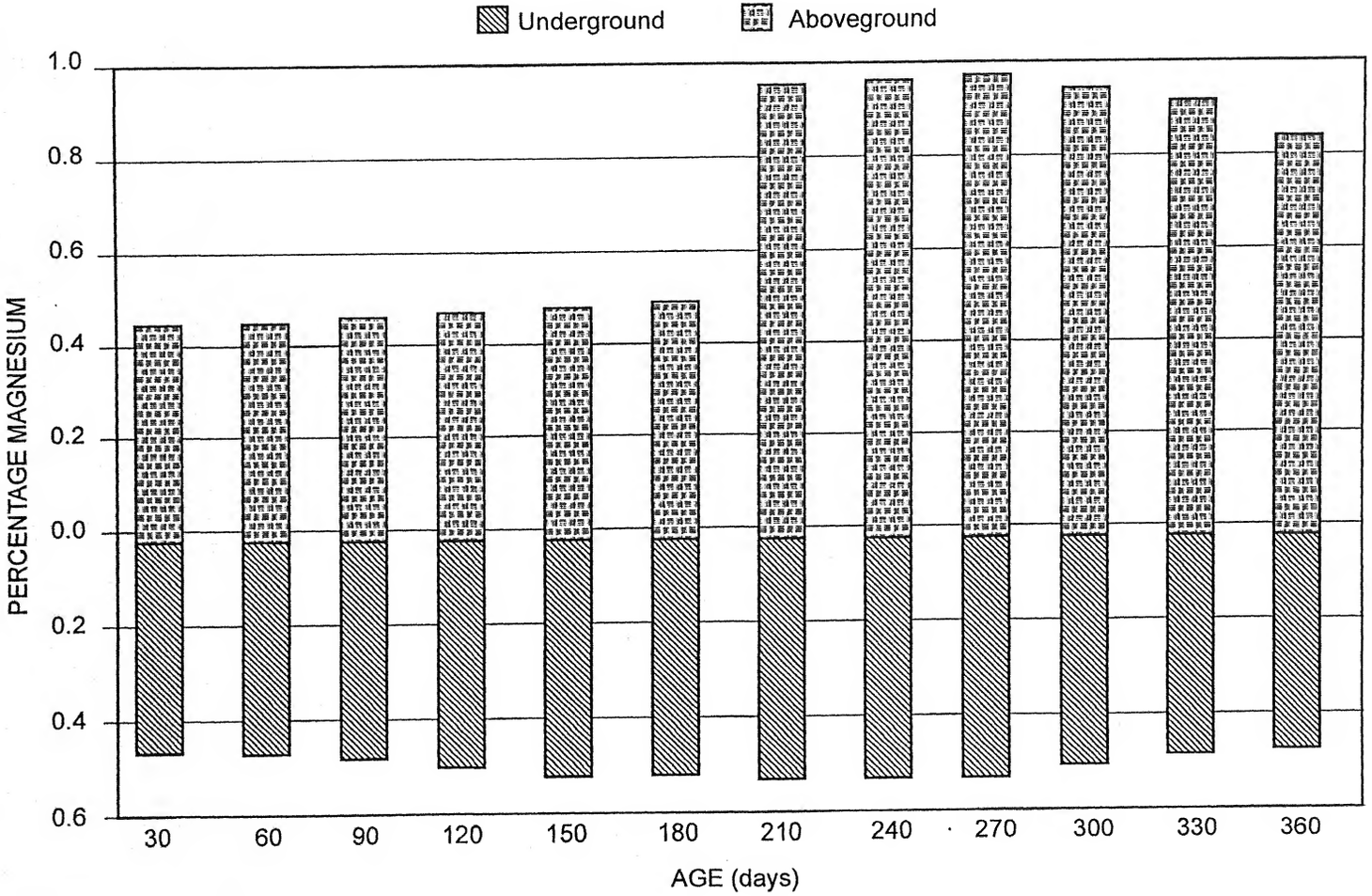


Fig. 8.11 : Percentage total magnesium in aboveground and underground part of *Crinum defixum*

**Table 8.15** : Uptake, release and retention ($g/m^2/day$) of calcium by *Crinum defixum*

| Age (Days) | Uptake | Release | Retention |
|---|---|---|---|
| 30 | 0.0073 | - | 0.0073 |
| 60 | 0.0084 | - | 0.0084 |
| 90 | 0.0093 | - | 0.0093 |
| 120 | 0.0125 | - | 0.0125 |
| 150 | 0.0142 | - | 0.0142 |
| 180 | 0.0140 | - | 0.0140 |
| 210 | 0.0137 | 0.0003 | 0.0134 |
| 240 | 0.0139 | 0.0004 | 0.0135 |
| 270 | 0.0138 | 0.0008 | 0.0130 |
| 300 | 0.0125 | 0.0010 | 0.0115 |
| 330 | 0.0116 | 0.0013 | 0.0103 |
| 360 | 0.0107 | 0.0014 | 0.0093 |

**Table 8.16 :** Percentage of total magnesium in the different components of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | (Bulb & Root) |
| 30 | 0.47 ± 0.056 | - | 0.46 ± 0.064 |
| 60 | 0.47 ± 0.005 | - | 0.46 ± 0.065 |
| 90 | 0.48 ± 0.001 | - | 0.47 ± 0.031 |
| 120 | 0.49 ± 0.058 | - | 0.49 ± 0.052 |
| 150 | 0.50 ±0.001 | - | 0.51 ± 0.106 |
| 180 | 0.51 ± 0.008 | - | 0.51 ± 0.061 |
| 210 | 0.52 ± 0.005 | 0.46 ± 0.055 | 0.52 ± 0.072 |
| 240 | 0.52 ± 0.001 | 0.47 ± 0.007 | 0.52 ± 0.000 |
| 270 | 0.53 ± 0.063 | 0.47 ± 0.082 | 0.52 ± 0.051 |
| 300 | 0.51 ± 0.031 | 0.46 ± 0.053 | 0.49 ± 0.101 |
| 330 | 0.49 ± 0.012 | 0.45 ± 0.032 | 0.47 ± 0.005 |
| 360 | 0.43 ± 0.008 | 0.43 ± 0.051 | 0.46 ± 0.012 |

± = Standard Deviation

**Table 8.17** : Accumulation of magnesium ($g/m^2$) in the different parts of *Crinum defixum* (dry weight basis)

| Age | Aboveground | | Underground |
|---|---|---|---|
| (Days) | Standing live | Standing dead | |
| 30 | 0.026 | - | 0.064 |
| 60 | 0.062 | - | 0,147 |
| 90 | 0.109 | - | 0.240 |
| 120 | 0.156 | - | 0.485 |
| 150 | 0.192 | - | 0.732 |
| 180 | 0.271 | - | 0.811 |
| 210 | 0.314 | 0.040 | 0.911 |
| 240 | 0.341 | 0.035 | 1.062 |
| 270 | 0.320 | 0.087 | 1.173 |
| 300 | 0,283 | 0.120 | 1.129 |
| 330 | 0.240 | 0.158 | 1.108 |
| 360 | 0.183 | 0.192 | 1.106 |

**Table 8.18 :** Uptake, release and retention ($g/m^2/day$) of magnesium by *Crinum defixum*

| Age (Days) | Uptake | Release | Retention |
|---|---|---|---|
| 30 | 0.0030 | - | 0.0030 |
| 60 | 0.0042 | - | 0.0042 |
| 90 | 0.0043 | - | 0.0043 |
| 120 | 0.0053 | - | 0.0053 |
| 150 | 0.0061 | - | 0.0061 |
| 180 | 0.0060 | - | 0.0060 |
| 210 | 0.0060 | 0.0001 | 0.0059 |
| 240 | 0.0059 | 0.0002 | 0.0057 |
| 270 | 0.0058 | 0.0003 | 0.0055 |
| 300 | 0.0051 | 0.0004 | 0.0047 |
| 330 | 0.0045 | 0.0004 | 0.0041 |
| 360 | 0.0041 | 0.0005 | 0.0036 |

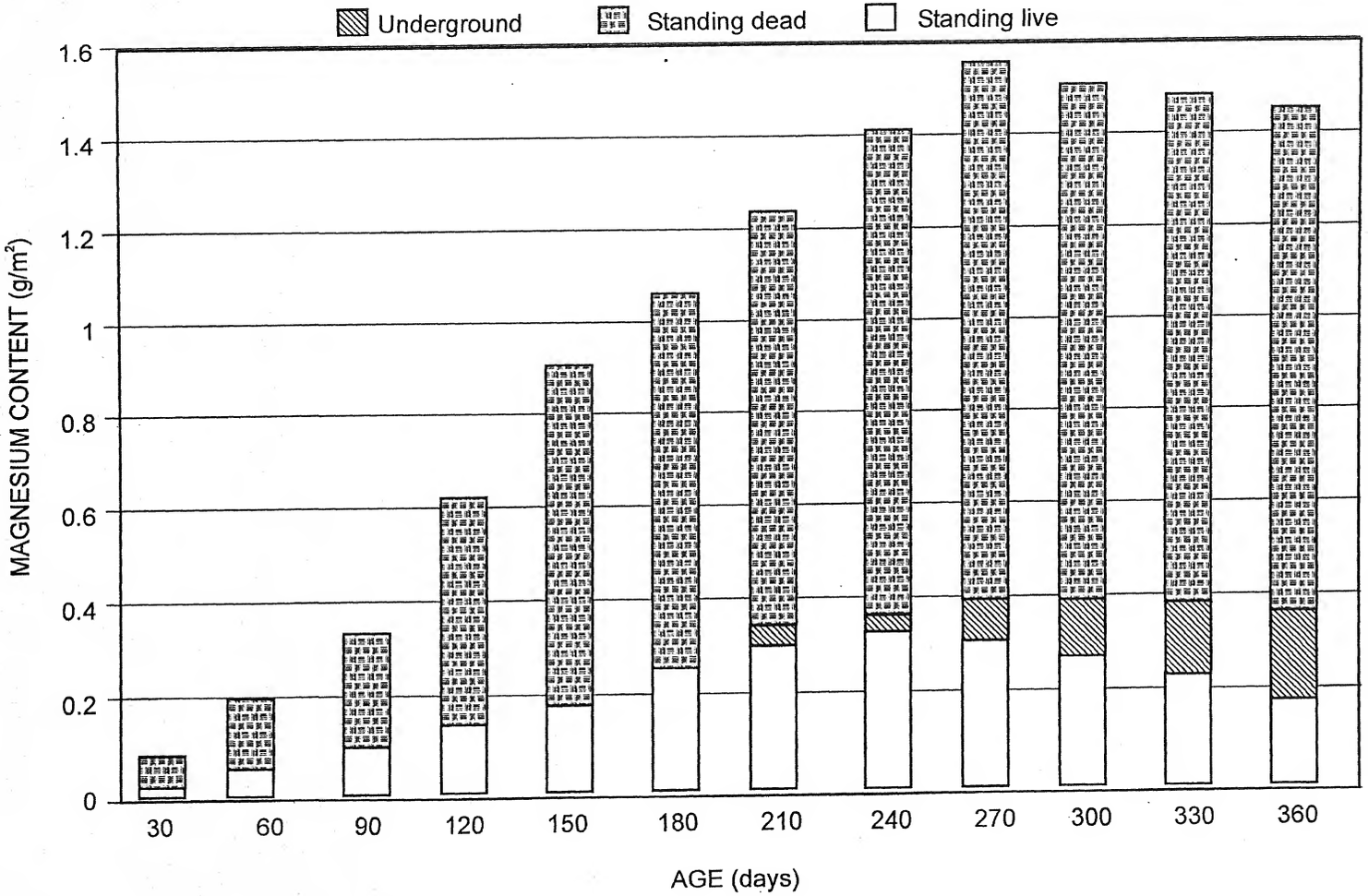


Fig. 8.12 : Total magnesium content ($g/m^2$) in component part of *Crinum defixum*

Later on it decreased to 1. 106 g/m$^2$ at 360 days of final harvest (Table 8.17). Accumulation of magnesium in total plant was increased up to the age of 270 days of plant growth after this it decreased (Figure 8.12).

The uptake of magnesium was found to be maximum of 0.0061 g/m$^2$/day at 150 days of growth (Table 8.18). Later on it decreased to 0.0041 g/m$^2$/day at 360 days of growth. The release of magnesium was reported to be 0.0001 to 0.0005 g/m$^2$/day between 210 and 360 days of plant growth. The maximum retention of magnesium was recorded 0.0061 g/m$^2$/day at 150 days of plant growth (Table 8.18).

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# CHAPTER - IX

# PHYTOCHEMICAL STUDIES

# PHYTOCHEMICAL STUDIES

Phytochemical study of any plant reveals the presence of various chemical constituents in the different plant parts and the amount of chemicals in the plant body. The chemical constituents of plant are responsible for the use of plant as a drugs in the medical science. Thus it is necessary to know about the phytochemistry before going to make the use of plant for human health. The medicinal properties of plant depend on the presence of different types of alkaloids, amino acids, phenols, sugars and steroids.

Sudarshan has been valued for its bulb and leaves which is used as a medicine. Current research reveals that sudarshan is valuable as an insecticidal, antibacterial and antifungal agent.

## RESULT

### Qualitative Studies

The phytochemical study of *Crinum defixum* shows that total ash content of this species is 7.241% and acid insoluble ash is 1.281% (Table 9.1). The percentage solubility in water and alcohol (Ethanol) is 33.963% and 25.584% respectively (Table 9.2).

**Table 9.1 :** Perentage of ash value in *Crinum defixum*

| | |
|---|---|
| Total ash | 7.241 ± 0.53 |
| Acid insoluble ash | 1.281 ± 0.15 |

± = Standard error

**Table 9.2 :** Perentage of ash solubility in *Crinum defixum*

| | |
|---|---|
| Solubility in water | 33.963 ± 1.82 |
| Solubility in alcohol | 25.584 ± 0.97 |

± = Standard error

The percentage extractive value of *Crinum defixum* in different solvents i.e. chloroform, alcohol, benzene and water shows 0.54%, 5.02%, 0.86% and 19.92% respectively (Table 9.3).

Observation of different extracts i.e. chloroform, alcohol, benzene shows (Table 9.4), the presence of different chemical constituents i.e. alkaloid, reducing sugar, protein, volatile oil, mucilage, lignin, cutin, suberin in the different plant parts.

**Quantitative Studies**

Table 9.5 shows the percentage of total alkaloid, total sugar, total nitrogen and protein content i.e. 0.31%, 8.34%, 2.02% and 15.87% respectively.

From the perusal of Table 9.6 it appeared that the alkoloid content increases with increase in the age of plant. The highest value obtained was 0.315% at 360 days of plant and then it decreased.

**Table 9.3 :** Perentage extraction value of *Crinum defixum*

| Solvent used | Percentage of Extractive Value |
|---|---|
| Chloroform | 0.54 ± 0.03 |
| Alcohol | 5.02 ± 0.08 |
| Benzene | 0.86 ± 0.02 |
| Water | 19.92 ± 0.94 |

± = Standard error

**Table 9.4 :** Perentage of alkaloid, sugar, nitrogen and protein content in *Crinum defixum*

| | |
|---|---|
| Total alkaloid | 0.31 ± 0.15 |
| Total sugar | 8.34 ± 0.74 |
| Total nitrogen | 2.02 ± 0.21 |
| Total protein | 15.87 ± 0.86 |

± = Standard error

**Table 9.5 :** Presence of different chemical constituents in different extract of *Crinum defixum*

| Chemical constituent in extract | Chloroform | Alcohol | Benzene | Water |
|---|---|---|---|---|
| Alkaloid | + | + | - | + |
| Reducing sugar | - | + | - | + |
| Protein | - | ++ | - | ++ |
| Volatile Oil | + | - | + | - |
| Mucilage | - | + | - | + |
| Lignin | - | + | - | + |
| Cutin | - | + | - | - |
| Suberin | - | + | - | + |

\+ indicates the presence

\- indicates the absence

**Table 9.6 :** Percentage of alkaloid content in bulb + root of *Crinum defixum* under different age groups

| Age (days) | Alkaloid content (%) |
|---|---|
| 90 | 0.037 ± 0.002 |
| 150 | 0.084 ± 0.005 |
| 210 | 0.152 ± 0.007 |
| 270 | 0.185 ± 0.007 |
| 330 | 0.293 ± 0.009 |
| 360 | 0.315 ± 0.015 |
| 390 | 0.313 ± 0.031 |
| 420 | 0.291 ± 0.014 |

± = Standard error

# CHAPTER - X

# PHARMACOLOGICAL STUDIES

## PHARMACOLOGICAL STUDIES

Next to food for sustaining life man's dependence on the plant life for health as well as fighting diseases has been as old as human existence. Along with the development of the Ayurved as a science of life & health, about 3000 years ago, studies have also been made in identification of plants medicinal value and also about their quality, uses and remedies for specific diseases.

The use of any plant in the form of medicine for human being is possible through its experimental studies which is basic needs to observe the action of a known or unknown drugs in physiological and pathological conditions. The experimental studies of the particular drug is based on the literary and field survey about particular drug yielding plant.

The bulb of *Crinum defixum* contains an aromatic bitter compound which has caused the plant to be regarded as medicinal. It constitute the bulb and is made into a confection which is considered a good stomachic and is eaten freely during the prevalence of the epidemic diseases. Mr. Pereira says that although it is rarely employed in medicine it might frequently be substituted

by other more costly aromatics. It is adopted to cease dyspepsia or as an adjunct to tonics or to purgatives.

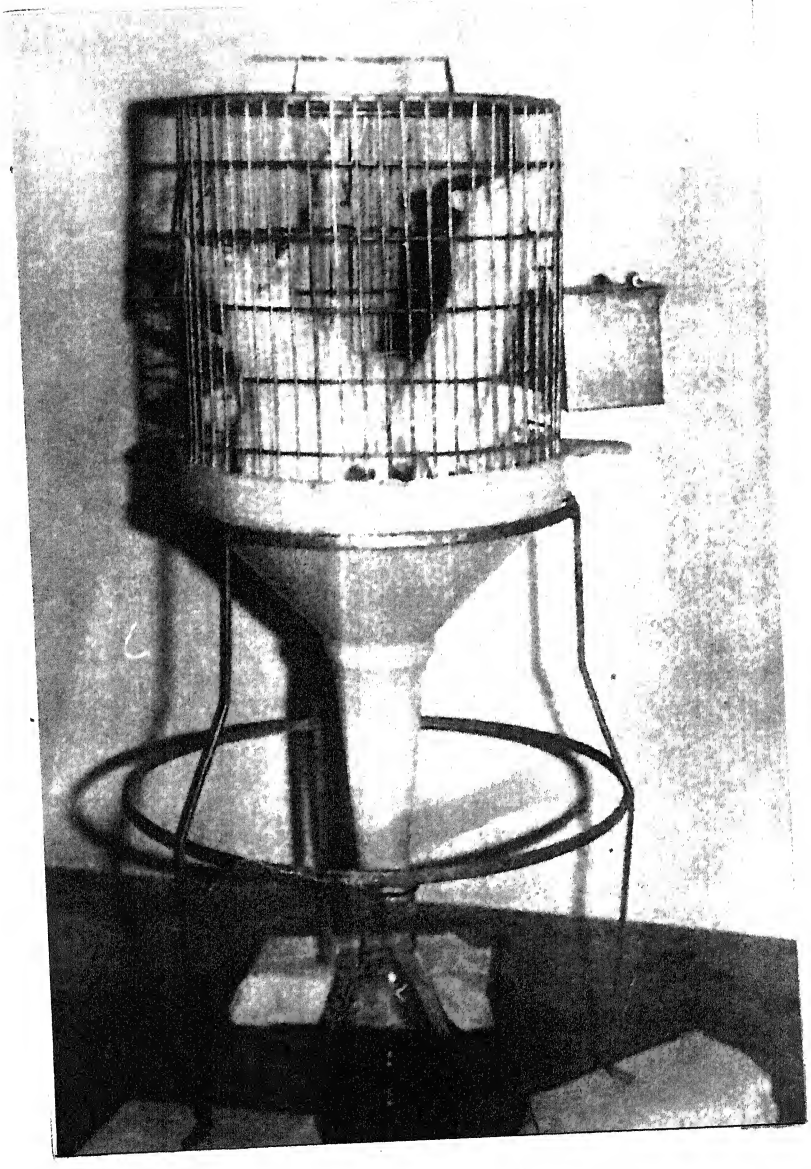
The aim of present study is that the drug of *Crinum defixum* may be used as diuretic in condition of fluid retention leading to Oedema. Necessary investigation like identification, monoculture, phytochemistry and electrolytic study of the drug have been performed to support the present work.

## MATERIALS AND METHODS

The present study was conducted on normal, adult, healthy albino rats of SRL strain of either sex, weighing about 100-150 g. All the animals were kept under identical housing condition, they were maintained on standard Hindustan Lever pellet diet. Animals were acclimatized to laboratory condition for 10 days before using them.

For the quantitative observation of metabolic output products i.e. urine and faeces of the animal, the metabolic cage (Plate IV) is used. The metabolic output products are generally suspended over the device which separates urine and faeces and permits separate collections. It consists of a round cages made up of half an inch wiremesh. A plastic funnel is fixed at the bottom of cage which in turn is mounted in the frame, three legs rest on the surface of the rack and help to support the cage. The stem of the funnel passes

**Plate IV :** Showing metabolic cage with albino rat to observe metabolic output products.



through the hole into urine glass jar which is meant for collection of urine. To obtain the perfect result the maintenance of the cage is necessary i.e. efficiently cleaning and avoidance of contamination.

## Drugs

(a) Control, 2.5 ml and 5 ml of 0.9% Normal Saline Solution.

(b) Ethanol alcohol extract of *Crinum defixum,* 5 mg and 10 mg/ml/ 100 g body weight.

(c) Decoction of *Crinum defixum,* 5 mg and 10 mg/ml/100 g in body weight.

## Preparation of Drug Extract

**Ethanol alcohol extract of *Crinum defixum* :**

100 g of dried plant materials i.e. bulb with roots in the form of coarse powder was used for alcoholic extraction. Extraction was obtained by hot continuous extraction method in soxhlet extractor, using rectified spirit as solvent.

**Decoction of *Crinum defixum* :**

The decoction of drug was prepared according to Singh and Sisodia (1971). The 100 g dried plant materials i.e. bulb and roots in the form of coarse powder was boiled with 800 ml of distilled water till the volume remained 100 ml. These mixture are filtered and stored in refrigerator for the use.

These extracts dose were determined on the basis of crude drug weight. The standard dose of the crude dry drug is 5 mg per 60 kg body weight which is the standard adult human body weight. The dose of the extracts were determined in the same ratio on the basis of presently yielded extracts from the drug. According to the standard doses determined for experiment, 5 mg/ml and 10 mg/ml of body weight of animal were taken as single dose and double dose respectively. The drug was dissolved in distilled water and the solution was prepared in per milliliter concentration i.e. 5 mg and 10 mg/ml/100 g body weight of animal.

The experimental work conducted on three groups of four animals (albino rats) in each group and had three replicates. First group served as control and was given 2.5 ml and 5.0 ml of 0.9% normal saline, while the other two groups were given the test drugs of 5 mg as single dose and 10 mg as double dose in every experiment. Food and water was withdrawn from the administration of drug for all the groups of albino rats. Before two hours of the drug administration, all the groups of albino rats were given 2.5 ml and 5 ml of 0.9% of normal saline per 100 g body weight (Gujral *et al.*, 1955). Then the test drug was administered in the dose of 5 mg and 10 mg/ml/100 g body weight of albino rats. These drugs were given orally through introgastric catheter. After the administration of the test drugs albino rats were transferred to their metabolic cages

and after 24 hours the total urine were collected from each metabolic cage. For obtaining the sufficient data, this process was repeated atleast 3 times.

For the study of diuretic effect of the drug the following parameters were adopted.

**Body Weight :**

After each experiment the body weight of each albino rat was recorded.

**Urine Output :**

After 24 hours duration of the drug administration, the urine volume of each albino rat was measured with the help of measuring cylinder.

**Electrolytes :**

The electrolytes of urinary and serum were estimate following the method described by Wootton (1964). The serum sample collected by administering the capillary needle through retinal artery after every experiment. The electrolytes i.e. sodium and potassium were determined by using Lange's model 6 Flamephotometer. Except these physical examinations of urine such as colour and general appearance, the amount of sediment was also observed.

## OBSERVATION AND RESULTS

The administration of the single dose of alcoholic and aqueous extract of drugs to each set of albino rat, the net reduction of weight was calculated as mean weight loss (Table 10.1 and Figure 10.1). The alcoholic extract showed significant weight loss than the aqueous extract i.e. 5.87 g.

After the administration the double dose i.e. 10 mg/ml/ 100g body weight, the net loss of weight is recorded (Table 10.2). The weight loss in administration group when compared with control group was statistically significant (Figure 10.1)

When administering the single dose of alcoholic and aqueous extracts of the drug there was not a significant induction of diuresis but there was increase in little amount in urinary output i.e. 39.82 ml and 36.27 ml respectively (Table 10.3 and Figure 10.2).

The double dose of alcoholic and aqueous extract of the drugs have induced significant amount of diuresis and increased urinary output i.e. 44.53 ml and 42.86 ml respectively. (Table 10.4 and Figure 10.2).

The excretion of sodium in urine after administration of drug in single and double dose is observed. It was obvious from Table 10.5 and 10.6 that the aqueous extract has increased the

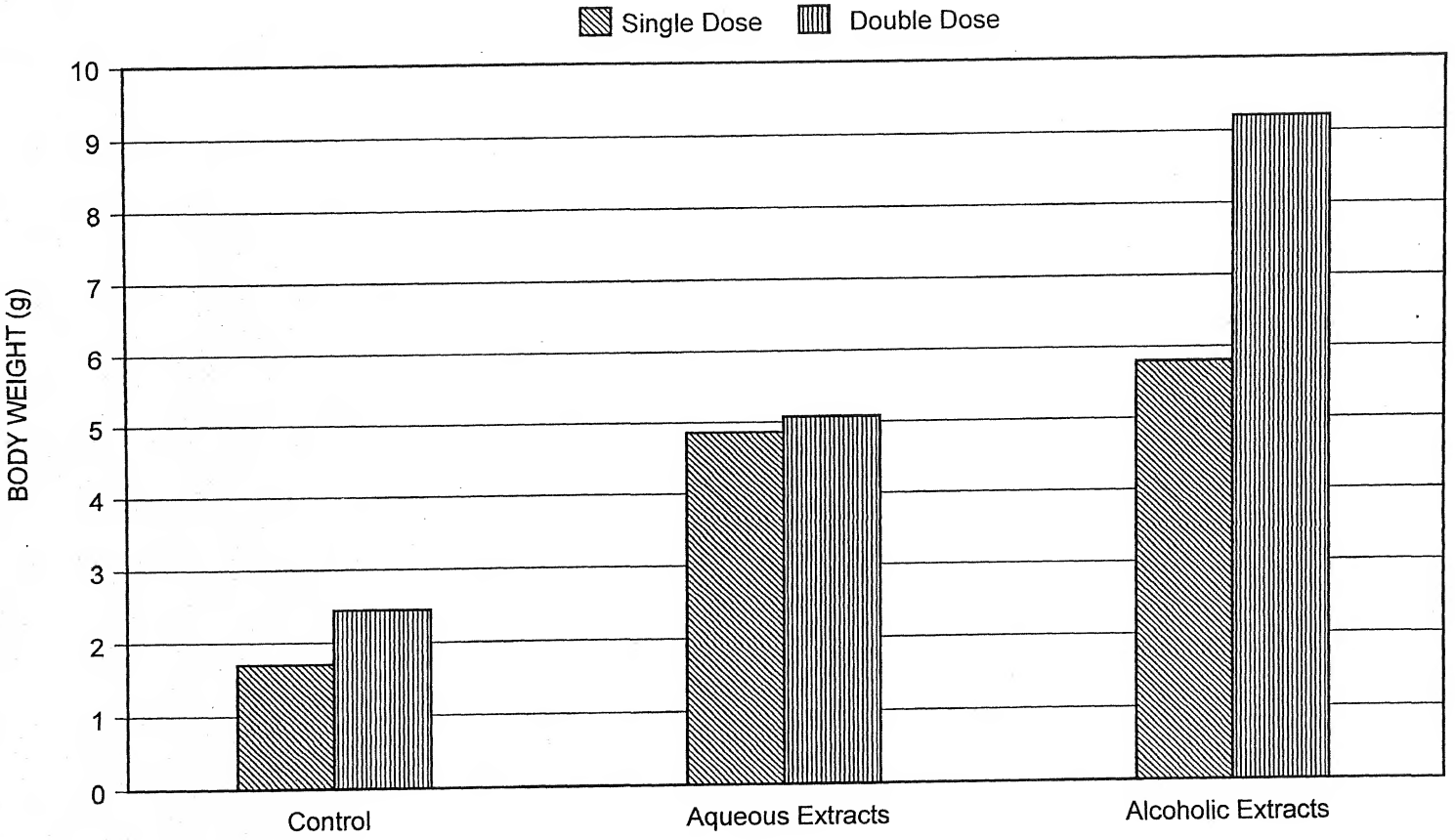



Fig. 10.1. Comparison between reduction in net weight (g) of albino rats after administration of single dose and double dose drug during 24 hours

**Table 10.1 :** Showing reduction in net weight (g) of albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 1.78 | 4.95[a] | 5.87[c] |
| ± 0.19 | ± 0.34 | ± 0.53 |
| | a = P < 0.001 | c = P < 0.005 |

± = Standard error

**Table 10.2 :** Showing reduction in net weight (g) of albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 2.53 | 5.14[a] | 9.25[c] |
| ± 0.35 | ± 0.56 | ± 0.87 |
| | a = P < 0.005 | c = P < 0.008 |

± = Standard error

**Table 10.3 :** Showing increase in urine volume (ml) of albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 31.63 | 36.27* | 39.82[c] |
| ± 0.35 | ± 0.62 | ± 0.46 |
| | * P = Non significant | c = P < 0.05 |

± = Standard error

**Table 10.4 :** Showing increase in urine volume (ml) of albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 38.35 | 42.86[a] | 44.53[c] |
| ± 0.26 | ± 1.52 | ± 0.97 |
| | a = P < 0.05 | c = P < 0.01 |

± = Standard error

**Table 10.5 :** Showing changes of urinary sodium (meq/l) in albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 31.63 | 38.56* | 34.34* |
| ± 0.36 | ± 0.85 | ± 0.79 |

* P = Non significant

± = Standard error

**Table 10.6 :** Showing changes of urinary sodium (meq/l) in albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 33.52 | 45.68* | 42.31* |
| ± 1.03 | ± 0.97 | ± 0.89 |

* P = Non significant

± = Standard error

natriuresis i.e. 38.56 meq/l and 45.68 meq/l in single and double dose respectively. Table 10.5 and 10.6 show the excretion of sodium in urine. These values were statistically significant when compared with control group (Figure 10.3)

Table 10.7 and 10.8 show the excretion of potassium in urine in control, aqueous and alcoholic extract i.e. 36.07, 39.62 and 42.38 meq/l respectively after administration of drug in single dose and 38.73, 40.63 and 43.25 meq/l in double dose respectively. Figure 10.4 shows statistically insignificant values.

After the administration of control, single and double dose, the serum sodium value were 82.65 and 86.00 meq/l in control group, 89.73 and 92.57 meq/l in aqueous group and 96.25 and 98.42 meq/l in alcoholic group respectively (Table 10.9 and 10.10). When these values commensurated with the increase in urinary sodium and urinary volume signify the natriuretic property of the drug (Table 10.9, 10.10 and Figure 10.5).

The serum potassium levels after administration of single and double dose were 4.23 and 4.82 meq/l in control group, 4.96 and 5.31 meq/l in aqueous group and 5.00 and 5.87 meq/l in alcoholic extract group (Table 10.11, 10.12 and Figure 10.6).

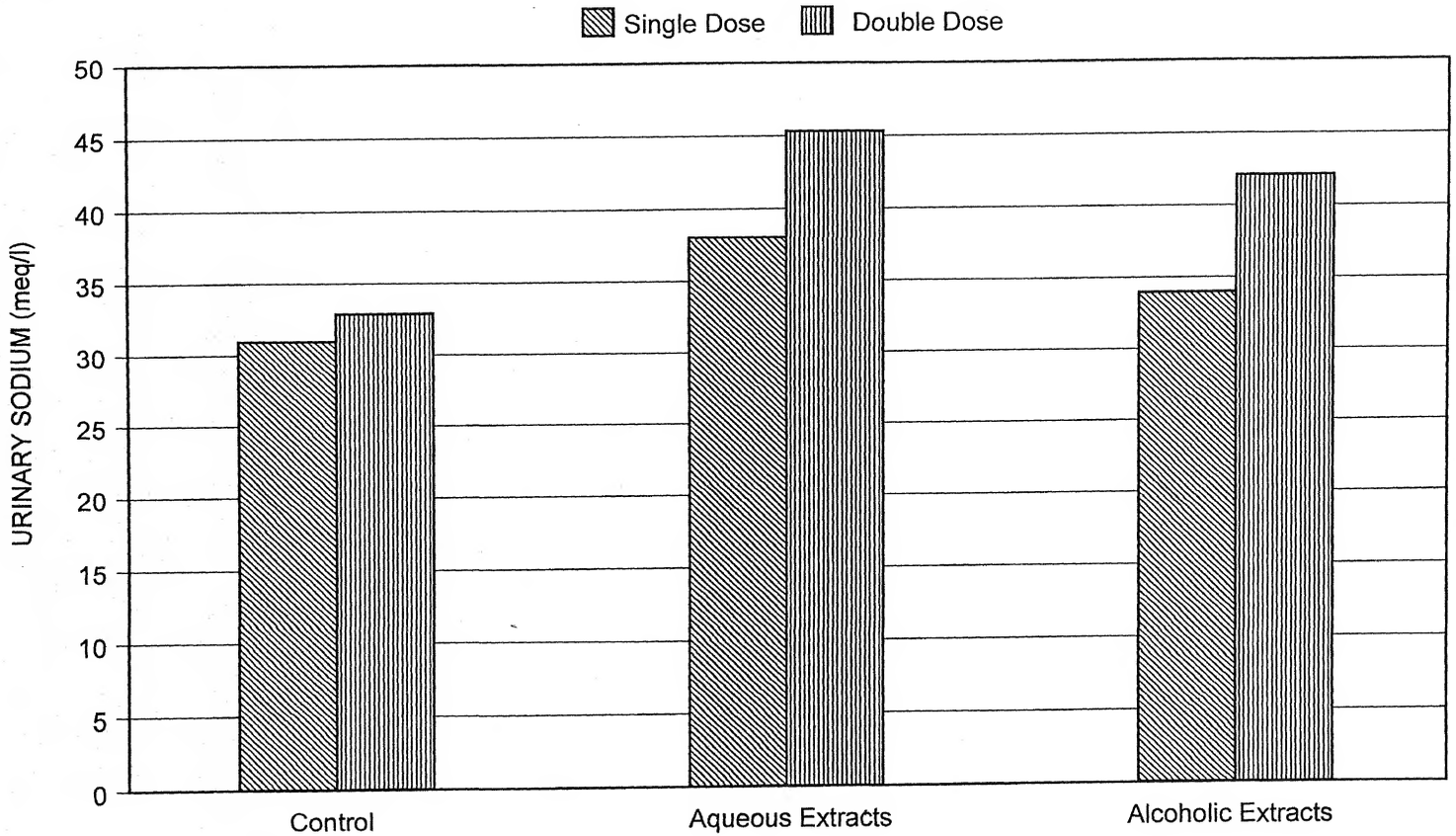



Fig. 10.3. Comparison between urinary sodium in albino rats after administration of single does and double dosė drug during 24 hours

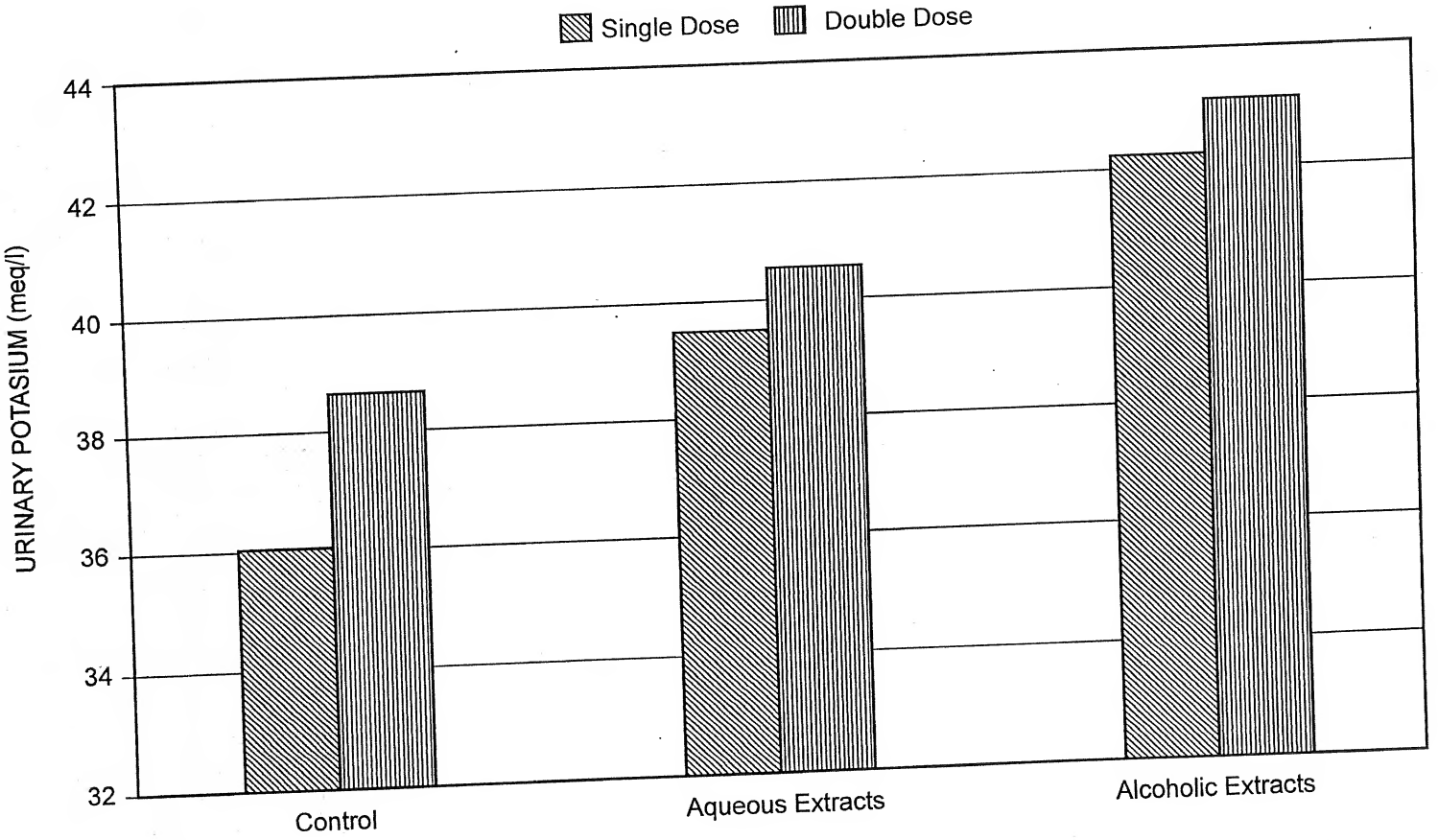



Fig. 10.4 : Comparison between urinary potasium in albino rats after administration of single and double dose drug during 24 hours

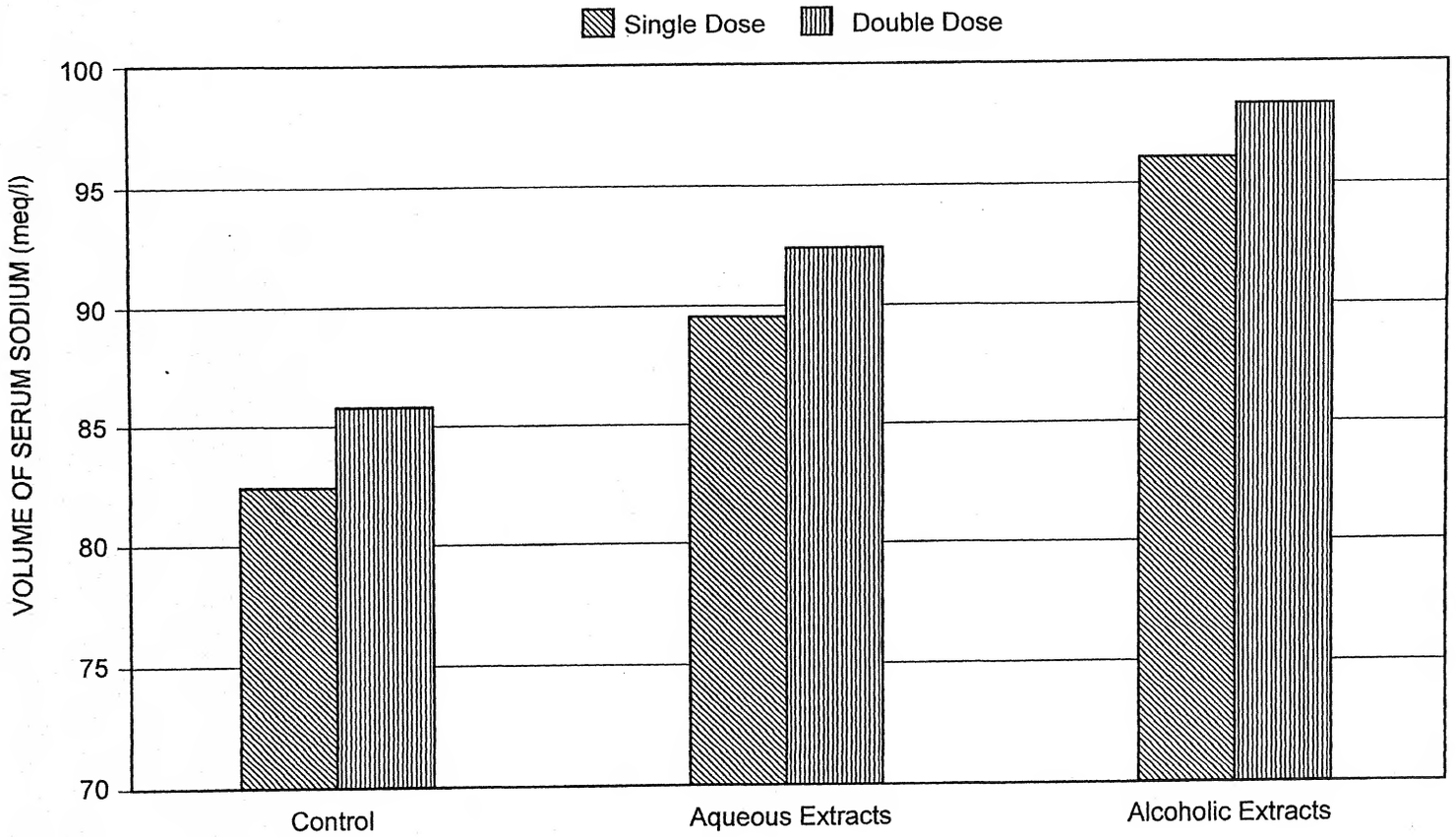



Fig. 10.5 : Comparison between value of serum sodium in albino rats after administration of single and double dose drug during 24 hours

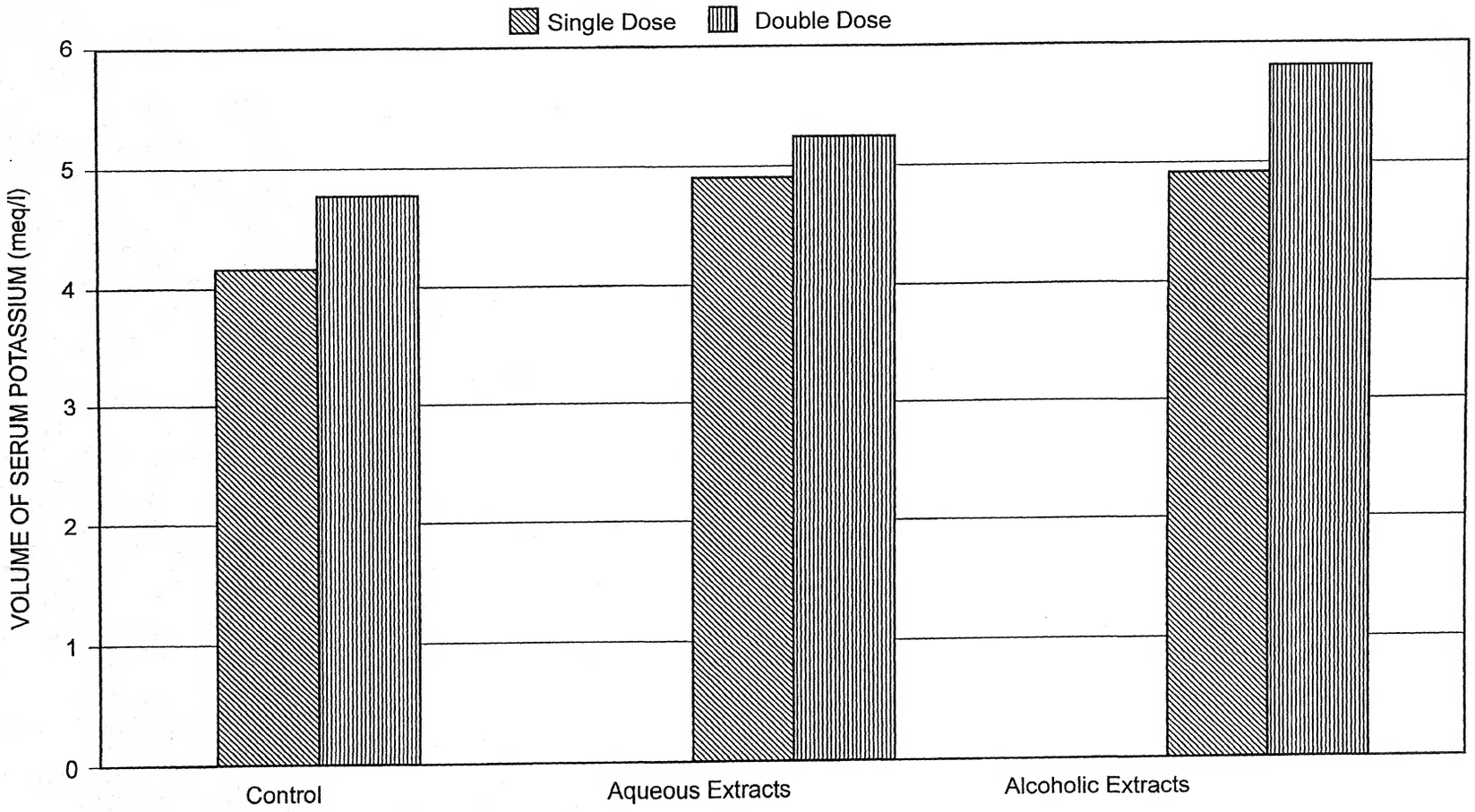



Fig. 10.6 : Comparison between value of serum potassium in albino rats after administration of single and double dose drug during 24 hours

**Table 10.7 :** Showing the changes in urinary potassium (meq/l) in albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 36.07 | 39.62[a] | 42.38[c] |
| ± 1.25 | ± 0.92 | ± 1.62 |
| | a = P < 0.05 | c = P < 0.005 |

± = Standard error

**Table 10.8 :** Showing the changes in urinary potassium (meq/l) in albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 38.73 | 40.63[a] | 43.25[c] |
| ± 0.95 | ± 1.24 | ± 1.50 |
| | a = P < 0.05 | c = P < 0.005 |

± = Standard error

**Table 10.9 :** Showing the changes in values of serum sodium (meq/l) in albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 82.65 | 89.73[a] | 96.25[a] |
| ± 1.53 | ± 1.24 | ± 2.95 |
| | a = P < 0.005 | |

± = Standard error

**Table 10.10 :** Showing the changes in values of serum sodium (meq/l) in albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 86.00 | 92.57[a] | 98.42[c] |
| ± 2.31 | ± 1.83 | ± 3.63 |
| | a = P < 0.05 | c = P < 0.005 |

± = Standard error

**Table 10.11 :** Showing the changes in values of serum potassium (meq/l) in albino rats after introduction of drug in single dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 4.23 | 4.96* | 5.00* |
| ± 0.31 | ± 0.42 | ± 0.67 |

*P=Non significant

± = Standard error

**Table 10.12 :** Showing the changes in values of serum potassium (meq/l) in albino rats after introduction of drug in double dose during 24 hours

| Control | Aqueous extracts | Alcoholic extracts |
|---|---|---|
| 4.82 | 5.31* | 5.87* |
| ± 0.33 | ± 0.53 | ± 0.25 |

*P=Non significant

± = Standard error

# CHAPTER - XI

# DISCUSSION

# DISCUSSION

## ESTABLISHMENT STUDIES

The effect of temperature variations on establishment was studied and the observation indicated that low and high temperature adversely affected the percent bulb buds establishment. Shorter exposure of temperature variation became sufficient to render the bulb to establish at higher percentage.

Most suitable temperature range for establishment was found to be between 20$^0$C to 25$^0$C. An increase in percentage germination with an increase in temperature between 5$^0$C to 20$^0$C was noticed. This may be due to increase in metabolic process involved in establishment of the bulb. Subsequent decreasing trend of establishment is indicative of high temperature injury to the lining cells and hormonal and enzymatic activity. Activity of enzyme appears to be at least maximum at a certain optimum temperature, but it decreases usually on either side of this value (Mayer *et al.* 1960) at maximum and minimum temperature but reaches at its highest activity at optimal temperature.

The effect of water irrigation level on establishment of the bulb was studied and the observation pointed out that high and low

water stress adversely affect the percent establishment.

The result indicated that the decreasing moisture stress increased the percentage establishment of bulb and found highest establishment of bulb at well moisturised pot which was watered after two days interval and saturated at the time of watering. After this level of watering, when the water stress decreases more, the percentage establishment of vegetative buds was also decreased. This shows that the metabolic activity of bulb involved in establishment are higher at a definite level of water stress.

## FERTILIZER APPLICATION

Oven dry weight in present consideration followed the increasing trend as the plant advances in age. The accumulation of biomass and the productivity was maximum in phosphorus treated plant and decreased in nitrogen and potassium treatments respectively. The result obtained here justify the role of phosphorus in growth of plants. External supply of phosphorus is readily available to plants which was in the adequate moisture conditions. Phosphorus was used in the form of calcium phosphate, which changes with the contact of soil in anions $H_2PO_4^-$ and cations $Ca^{++}$ in the presence of water. In neutral and alkaline soils most phosphate fixation apparently results from precipitations by calcium and magnesium. In this experiment the calcium are present in the

form of cations Ca++, which is taken by the plant in this form and it is necessary for the continued growth of the apical meristems. Phosphorus being an essential element for the metabolic functions, it regulates the photosynthetic activity there by increasing or decreasing the plant weight.

The percentage contribution of leaf dry weight at each growth stage is higher in phosphorus supplied plant and least in potassium given plant. The plants grown in higher level of nitrogen were much green for longer period, increasing the percentage of green parts. Pathak (1967) and Lalman (1972) noted that plants grown in higher level of nitrogen were much green for longer period.

## PHOTOPERIOD

Knowledge of photoperiodism is of great practical utility in selection of species and seasons of their -cultivation depending upon the plant parts which are economically important. Many phenological events are regulated by the rhythms of light and dark lengths in 24 hours diurnal cycle. The ecological understanding of responses of plant to different conditions of light is of great practical significance. Plant distributed in different geographical regions, in course of their long evolutionary history, have become ecologically adjusted to the light period of the place. Even within a

species there are examples of photoperiodic ecological races as in *Xanthium strumarium* (Kaul 1959).

In the present study, the effect of photoperiod on biomass and net primary productivity of *Crinum defixum* has been emphasised. The results indicate that the dry weight of vegetative parts i.e. bulb is highest in plant treated with 6 hours of light. The vegetative growth is promoted by 6 hours to 8 hours light treatment. The maximum biomass (16.805 g/plant) was obtained in plant exposed to light for 6 hours. The increase in duration of light induces the biomass and vegetative growth parts of plant. This property shows that plant is sciophytes in nature because it shows better growth in lower light condition. Similar result was noticed by several workers, such as, Bonner and Livermann (1953), Naylor (1953), Pathak (1967) and Lavania (1971).

Net primary productivity of *Crinum defixum* is found to be higher in the case of 6 hours light treated plant and it was decreased when the light period increased and minimum in 12 hours light period. The percentage contribution of dry weight of leaves is maximum in plant treated with minimum light period and decreased with increasing duration of light. These results explained the occurrence of the plant in winter season when the day length is shorter which is suitable for the vegetative growth of the plant.

## STANDING CROP BIOMASS

Standing crop biomass of *Crinum defixum* grown almost in uniform cultural condition was estimated at 30 days interval for 360 days, it was found that dry weight increased to a maximum of 328.19 g/m$^2$ between 30 and 360 days of growth. The increase in biomass is attributed to the accumulation of the photosynthesis. The growth has been reported to be sigmoidal in annuals (Friend *et al.*, 1962; Sant and Kumar, 1979; Pandey and Kumari, 1995). Although all the plants were grown in almost uniform cultural conditions.

Dry matter distribution ratio of the component parts of *Crinum defixum* was calculated, it was found that at 30 days growth period underground part contributed maximum (79.88%) to the total plant biomass. The contribution of standing live to the total plant biomass at 30 days growth was 28.88%. The contribution of standing dead to the total plant biomass contributed maximum value at the age of 360 days i.e. 13.64%. Monsi (1960), Asana and Wattal (1965) have observed that dry matter distribution ratio of vegetative and reproductive parts vary with stages of growth and environment. Loomis *et al.* (1971) have pointed out that the distribution pattern of photosynthate at each stage of growth was important in determining the ultimate size, from economic yield of the plant. Translocation of photosynthate from vegetative parts to

reproductive parts has been reported by many workers (Asana and Wattal, 1965; King *et al.*, 1967; Rawson and Evans, 1970).

## NET PRIMARY PRODUCTIVITY

Net primary productivity of aboveground and underground plant parts of *Crinum defixum* at 30 days interval was calculated for 360 days of stand development. It was found that the net primary productivity has increased upto 0.31 $g/m^2$/day (A.G.) and 0.85 $g/m^2$/ day (U.G.) at 240 days of growth period. Later on it showed decreasing trend. The initial increase of net primary productivity was indicative of high rate of photosynthesis and storage of materials which was associated with high leaf area index. The decline in productivity after 240 days was attributed to the decrease in the leaf area and senescene (Khokhar and Pandey, 1976; Dhingra, 1978; Kumar, 1984; Pandey and Nath, 1990; Pandey and Vihari, 1991; Pandey and Kumari, 1995).

## NUTRIENT DYNAMICS

Nitrogen, phosphorus, potassium, sodium, calcium and magnesium contents in the plant material were, analysed by dried plant samples of different plant parts at different age group of *Crinum defixum*. The concentration of these elements in plant varies with the age of the plant. Difference in the concentration of the minerals were due to metabolic activities at different stages of

growth. There was a gradual increase in the concentration of chemical elements in all the component parts upto the definite age. The concentration of nutrients declined throughout the plant more rapidly as dry matter accumulation diluted the elemental concentration. This trends in the elemental concentration of sudarshan reveals the concept of the nutrient redistribution in plants (Biddulph and Biddulph, 1959; Miller, 1967) which might be either due to withdrawal from the leaves before falling or translocation of nutrients to reproductive parts.

Further, the nutrient accumulation is largely influenced by age of the plant, biomass built up and the elemental concentration. According to Nye and Spiers (1964), Nye and Tinker (1977), decrease in nutrient content in later stages may be due to the decreasing rate of absorption by plant than the rate of dry matter production and utilisation. Nitrogen, phosphorus, calcium, sodium and potassium being important minerals for the synthesis of biologically active compounds show their predominant role towards total storage (Fried and Broeshart, 1967).

The trends of nutrient accumulation in the present study are dependent on sink size. Similar observations were made by Kollman *et al.* 1974; Nath, 1990; Vihari, 1992; Kumari, 1995 for these elements in soyabean, sunflower and niger plants, respectively. But, the calcium accumulation in the aboveground

parts of soyabean was not dependent on sink size (Kollman *el al.*, 1974).

It is evident from the trends described earlier that maximum part of the nitrogen, phosphorus and calcium is amassed to the aboveground plant production. Williams (1955), stated that major percent of total nitrogen and phosphorus contents are absorbed when the dry weight is only 25 percent of the total value. These are initially absorbed by the initial growing leaves and then withdrawn to the newly formed leaves and inflorescence as the older leaves become senescent. Decrease in nitrogen and phosphorus content with increasing competition stress may be attributed to be ability of plant to maintain itself at low rates of nutrients supply which determines inherently slow rate of growth with increasing age, thus making a low demand on the supply power of the nutrient system (Clarkson, 1967).

The percentage calcium content of the plant increased throughout the growing period (Day and Monk, 1977) and thereafter decreased. This observation is in agreement with the findings of Mclean and Tisdale (1960), Smoliak and Bezeau (1965). Calcium is mainly incorporated in the structural component of plant principally as calcium pectate in the middle lamella of cell wall and also as calcium carbonate and calcium oxalate crystals (Epistein, 1972).

Calcium concentration decreased significantly with increasing competitive stress (Clarkson, 1969).

It is clear by the above mentioned pattern of sodium and potassium accumulation that the maximum part is channelized to the below ground plant production. Plant is rich in sodium and potassium content and their large quantities of potassium nitrate and other potassium salts (Chopra *et al.*, 1923; Anonymous, 1976).

It was noticed that the trend of uptake, retention and release of nutrients correspond with dry matter production a different growth stage. The maximum release of nutrients occurred through death of the living tissue of the sudarshan.

## PHYTOCHEMISTRY

### Qualitative Study

The qualitative studies of various extracts of plant *Crinum defixum* revealed the presence of different chemical constituent; i.e. alkaloid, reducing sugar, protein, volatile oil, mucilage, lignin, cutin and suberin in different plant parts. These chemicals show their presence mainly on alcoholic and water extract. According to Dipalidey and Das (1980) the oil cells, oleoresin mass and starch grains are embedded in the thin walled cells of the ground tissue, cortex and stele. Alkaloid, sugar, protein and such type of other

chemicals are present in the cells. They also observed pink coloured maximum fluorescence under UV radiation.

## Quantitative Study

The chemical study of essential oil obtained from root of *Crinum defixum* was first time studied by Rao and Watson (1925). The presence of alkaloids and essential oil in the leaves and bulb of the plant sudarshan was studied by Nigam and Rao (1970), Saxena (1986), Agarwal *et al.* (1997). Glandular cells and essential oil of the leaves and bulb of the plant was studied by Mericle *et al.* (1994). They obtained essential oils by water distillation. Essential oil content of the leaves and bulb was found to be 0.9-4.1 percent. Leaf oil and bulb oil were found moderately different but beta-asarone was determined as one of the major compounds of all the samples.

The percent value of the alkaloid present in the bulb and root of the plant was higher at 330-360 old days of plant and after this the alkaloid content was decreased. This may be due to the advancing age (post harvesting stage). After harvesting stage, the productivity and biomass of the plant remarkably declined. Nigam *et al.* (1987) reported a significant increase in the yield of essential oil because of the transformation of non-volatile glycosides to volatile mono and sesquiterpenoids. The maximum increase of essential oils

take place in those part of the plant which are reported to possess a significant portion of glycosides.

## PHARMACOLOGY

*Crinum defixum* is one of the most commonly used ingredient in Ayurvedic preparations. In the Charak Samhita (200 B.C.) the colebrate text on Ayurveda, recommends the use of Vacha for boosting recall. Rajagopalan (1995) prepared a mixture of three drugs, viz., 'Brahmi', 'Sudarshan' and 'Shankapushpi' in the ratio of 1000 mg, 380 mg, 20 mg respectively and tried in low grade mentally retarded children. The experimental group showed a significant increase of 7½ months during one year treatment, the central group registered only 2½ months rise in the non verbal mental age. An appreciable increase in verbal mental age was shown by the drug group as compared to the placebo group.

According to Thankamma *et al.* (1995) in Ayurvedic preparation of sudarshan the omission of an ingredient or use of adulterants not only reduces the efficacy of the drug to a great extent, but some times it is harmful to health. In this context any parameter evolved to detect the presence of an ingredient in a preparation goes to a long way in ensuring the quality of medicine. Though usually only costly/rare drugs are omitted or adulterated but

it is not uncommon for a commonly available drug to be omitted or adulterated.

Essential oil of plant sudarshan had been shown as a potent source of environmentally safe pesticides against various parts and could be exploited for the same on a large scale (Schmidt, 1993).

Sudarshan was used to control in urinal disorder from a long period of time. Drugs which are used as a diuretic to prevent reabsorption of water in the kidney tubule either by affecting the active ion transport or regulating the effect of hormones which are responsible for $Na^+$ and $K^+$ reabsorption. In present experimental studies diuretic properties of drug of sudarshan was studied on albino rats of SRL strain of either sex, weighing about 100-150 g. All the animals were kept under identical housing condition. The experimental work was conducted on three groups of four animals and three replicates. Group first served control, group second was administered aqueous extract of single and double dose and group third was administered alcohol extract of single and double dose. Before two hours of the drug administration all the groups of animals were given 2.5 ml and 5 ml of 0.9% normal saline.

The net reduction of weight calculated as mean weight loss showed significant weight loss which could be interpreted, due to loss of fluid. The weight loss increased when the double strength of

dose was used. The net reduction in the weight was more obvious in the alcoholic extract than the aqueous extract and when these compared with control group was statistically significant.

After the single dose administration of alcoholic and aqueous extracts there was not a significant increase in urinary out put but after double dose of drug a significant increase was observed in urinary output.

The excretion of sodium and potassium in the urine after administration of drug in single and double dose the increase was found in the sodium excretion in aqueous extract. In alcoholic extract though the excretion of sodium was more than the control group, but it was less than the aqueous extract. The excretion of urinary potassium did not show an increasing trend in comparison to sodium and it was also insignificant when compared with the control group.

When single and double dose of drug was administered, there was marginal increase in serum electrolyte i.e. sodium and potassium. The marginal increase in serum sodium is probably because of the water loss which impedes the electrolyte loss.

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# CHAPTER - XII

# SUMMARY

## SUMMARY

The present study concerned about **"Ecological study of *Crinum defixum* Ker. with special reference to phytochemistry and pharmacology in Bundelkhand region (U.P.)"** has been carried out in the Botanical Garden, D.V. Postgraduate College and Forest Nursery, Orai. The thesis contains the results of studies made on plant identification, establishment of bulb, field cultivation, fertilizer application, photoperiod effects, standing crop biomass, primary productivity, nutrient dynamics, phytochemistry and pharmacology.

*Crinum defixum* has been used since long time as in mental desorder, asthma, epilepsy and diuretics. Recently many workers have identified its insecticidal properties. The plants are found mostly in tropical regions but field cultivation studies show that plants are also cultivated at high level in eastern part of the upper Gangatic plain after proper maintenance, timely transplantation and irrigation. The better yield depends upon the fertility of the soil. Before planting, the field is ploughed 3-5 times and left for a few days with standing water. Following this technique the soil becomes soft and wet which allows the bulb to grow well.

The low and high temperature adversely affected the establishment of the bulb buds. The moist suitable temperature for the maximum establishment was found to be between 20$^0$C to 25$^0$C. The water stress study shows that the maximum establishment of bulb bud was found when watered after two days interval and saturated at the time of watering. It decreases with the increase of watering days intervals.

Nitrogen, phosphorus and potassium treatment on the plant shows that the dry weight of leaves is highest in phosphorus treated plant followed by nitrogen and potassium treated plant respectively. The increase in leaf weight is up to 300 days after which it declined. Same as leaves, the standing biomass of bulb with roots is highest in case of phosphorus treated plant followed by nitrogen and potassium treatment. The net primary production (g/plant/day) of whole plant was highest in case of phosphorus treated plant while the nitrogen and potassium treated plants stand second and third respectively. Percentage contribution of dry weight showed continuous increase in leaf and found to be highest in phosphorus treated plant followed by nitrogen and potassium treated plants respectively.

The photoperiodic effects on the plant revealed that the biomass of aboveground and underground parts is highest in 6 hr light period which declined afterwards and the standing crop

biomass of the plant treated with 12 hr light period is remarkably less. The net primary productivity was highest in case of 270-300 days old plant at 6 hr light period. The percentage contribution of biomass in leaf was highest in shorter duration of light at every stage of growth. It declined with increasing photoperiods and lowest value was found in 12 hr of photoperiod plant. In underground part i.e. bulb with root the percentage biomass contribution increased with age and was found highest at 360 days of plant.

The standing crop biomass of aboveground part i.e. in standing live increased gradually upto 62.25 $g/m^2$ at 270 days, after this it was decreased. In standing dead of the aboveground parts, the biomass was reported high at the age of 210 days and harvesting time i.e. 360 days of growth period and recorded highest i.e. 44.78 $g/m^2$ at 360 days of growth. In underground part i.e. bulb with root the biomass continuously increased and found highest (240 $g/m^2$) at 360 days of plant. The percentage contribution to the total plant biomass was recorded maximum (73.66%) by underground part at 330 days of plant. The net primary productivity of standing live part increased up to 180 days of growth and later on it decreased. In case of underground parts i.e. bulb with root, it was found maximum (1.59 $g/m^2$/day) at the age of 120 days of growth period and after this it was recorded decreasing up to harvesting period.

Nutrient concentration varies with the age of the plant. There was a gradual increase in the concentration of chemical elements in all the component parts up to a definite age. It is clear that the maximum percentage of nitrogen, calcium, phosphorus, potassium and magnesium are amassed in the aboveground parts of the plant. These elements were highest in standing live part of plant i.e. 1.55%, 1.23%, 1.82%, 1.51% and 0.53% at 270, 240, 180, 270 and 270 days of plant growth respectively, while the sodium is channelized to the below-ground part of the plant and recorded highest 0.98% at 270 days of plant growth.

Phytochemical studies revealed that oil cells, oleoresin mass and starch grains are embeded in the thin-walled cells of the ground tissue of cortex in bulb under microscopic studies. Microchemical tests for detection of nonprotoplasmic cell contents like alkaloid, sugar starch, fat, protein, mucilage oleoresin, lignin, cutin and suberin are present. The plant material was tested after subjecting to preliminary investigation by extracting the drug powder with different solvents i.e. benzene, chloroform, alcohol and water. Total ash content of species was recorded 7.241% and total alkaloid was 0.31%. Presence of alkaloid was recorded in alcohol and water extract and was highest in 330 to 360 days group of plants i.e. 0.293% to 0.315% after which it decreased.

Under pharmacological studies the experimental work was conducted on albino rats, in which the alcoholic and aqueous extract of bulb and roots of the plant showed diuretic property. Experimental work revealed that alcoholic extract had significant weight loss than the aqueous extract. It was observed that there was not a significant induction of diuresis when single dose i.e. 5 mg/100 g body weight of drug was given but there was little increase in the amount of urinary out put. After double dose i.e. 10 mg/100 g body weight the drug has induced significant amount of diuresis and increased urinary out put. It was observed that aqueous extract has increased the natriuresis i.e. sodium level in urine. Excretion of urinary potassium was not altered and values were statistically insignificant when compared with control group after the administration of the single and double doses. It does not have significant changes but maintained within normal range. These experimental works show that plant has diuretic property without affecting the serum electrolytes level.

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* Original not seen.

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